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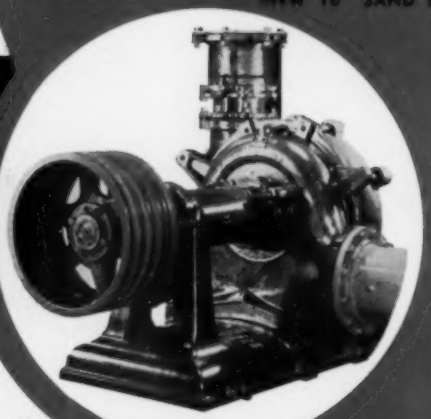

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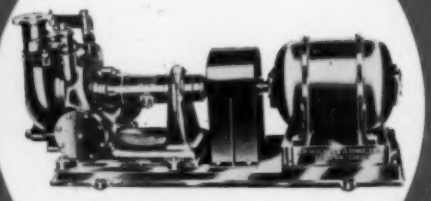

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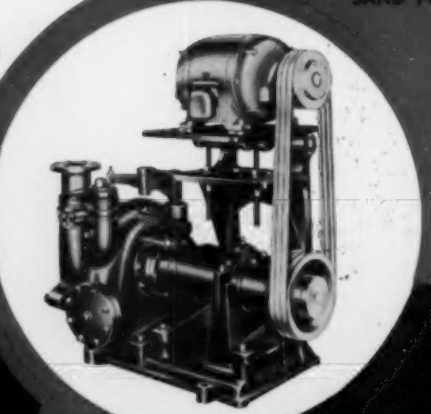

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COMING EVENTS

Dec. 11, AIME Utah Section, panel discussion on Place of Research in the Minerals Industries; members: chairman J. M. Ehrhorn, S. R. Zimmerley, J. B. Clemmer, W. M. Fassell, Jr., J. R. Lewis; Salt Lake City.

Jan. 5-9, 1959, 2nd Caribbean Geological Conference, University of Puerto Rico and Economic Development Administration of the Commonwealth of Puerto Rico, sponsors; University of Puerto Rico, Mayaguez, P.R.

Jan. 12, AIME Minnesota Section, annual meeting, Duluth.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Duluth.

Jan. 15, AIME Utah Section, speaker: H. Wright; subject: Rubber and Plastic as Cost Savers in Metallurgical Installations; Salt Lake City.

Feb. 5-6, California Governor's Industrial Safety Conference, Biltmore Hotel, Los Angeles.

Feb. 5-7, Centennial Celebration and Mining Convention, sponsored by Colorado Mining Assn. and others, Denver.

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Feb. 23-27, FluoSolids Symposium Part I, University of Arizona, Tucson.

February, AIME Lima, Peru, Section, subject: panel review of Peruvian Geology, Lima, Peru.

Mar. 1-4, Canadian Prospectors & Developers Assn., annual meeting and convention, Royal York Hotel, Toronto.

Mar. 2-3, FluoSolids Symposium Part II, University of Arizona, Tucson, Ariz.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 13-15, CIM, annual meeting, Queen Elizabeth Hotel, Montreal.

Apr. 16-18, AIME Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

Apr. 20-22, Third Rock Mechanics Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Colorado School of Mines, Golden, Colo.

May 8-10, Fourth Annual Uranium Symposium, AIME Uranium Section, Moab, Utah.

May 11-14, American Mining Congress, Coal Show, Cleveland.

June 15 (approx.) AIME Pittsburgh Section—SME Coal Division, joint meeting, Waynesburg, Pa.

June 28-July 1, Rocky Mountain Coal Mining Inst., annual meeting, Antlers Hotel, Colorado Springs, Colo.

Sep. 14-17, American Mining Congress, Metal Mining & Industrial Minerals Convention, Denver.

Sept. 24-26, SME Industrial Minerals and Coal Divisions, joint meeting, Bedford Springs, Pa.

Oct. 8-10, Exploration Drilling Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Pennsylvania State University, University Park, Pa.

Nov. 9-12, Society of Exploration Geophysicists, annual meeting, Biltmore Hotel, Los Angeles.

Dec. 7, AIME Arizona Section, annual meeting, Tucson, Ariz.

MINING engineering

Vol. 10 NO. 12 **DECEMBER 1958**

COVER *MINING ENGINEERING's annual Christmas card by Herb McClure is based this year upon an 18th century collection of Bohemian figurines. For a more detailed description of these mining musicians, turn to page 1237 and read a review of the German art book from which the idea came.*

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1259 Minerals for Insecticide Formulations • *H. T. Mulryan*

1261 Advances in Magnetic Separation of Ores • *L. A. Roe*

1266 Lucky Friday Mine: History, Geology, and Development • *W. T. Folwell*

1269 Magnetic Separation for Mesabi Magnetite Taconite • *J. E. Forciea, L. G. Hendrickson, and O. E. Palasvirta*

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PERSONNEL

THESE items are listings of the Engineering Societies Personnel Service Inc. This Service, which cooperates with the national societies of Civil; Electrical; Mechanical; Mining, Metallurgical, and Petroleum Engineers, is available to all engineers, members and nonmembers, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5 pct of the first year's salary if a nonmember, or 4 pct if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number. When making application for a position, include 8¢ in stamps for forwarding application to the employer and for returning when possible. A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for nonmembers, payable in advance. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 57 Post St., **San Fancisco**; 84 E. Randolph St., **Chicago 1.**

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Mining Engineer, E. M., age 30. With five years mining engineering experience including four years supervising, sampling, and ore-grade control in large uranium mine. Familiar with all administrative work. Good production record. Desires position in supervisory capacity, preferably Northeast, Midwest, or Northwest. M-450.

Project Engineer, civil and mining degrees, age 42. Seven years experience in steel construction, design, and erection in western Europe of bridges, lock and spillway gates, rivers and canals, and drydocks. Ten years work in mining, engineering, and supervising of metal mines in the U. S. and South America, experienced in underground and open pit mining and dump leaching. Location, immaterial. M-139-San Francisco.

Mining Engineer, age 50, thoroughly experienced in efficient management of large mining and exploration enterprises at high level of responsibility, both domestic and foreign. Presently employed as general manager of large South American mining property. Available immediately. M-451.

POSITIONS OPEN

Sales Engineer, mining graduate, with five years open pit or underground mining experience, to sell explosive accessories. Salary, $8,000 to $10,000 per year. Location, East and Northeast. W6522.

General Superintendent, expert in the processing of bentonite, particularly conversion of calcium bentonite into a sodium bentonite. Salary, open. Location, Greece. F6340.

General Superintendent, operations, to take over the supervision and coordination of operations of an underground copper mine, mill, and smelter. Salary, open. Location, South America. F6283.

District Sales Representative, for manufacturer of heavy construction and mining equipment. Must be experienced in application of excavating and loading equipment. Sales experience desirable. Headquarters, New York. W6179.

Mine Engineer, underground, iron, E. M. Must be qualified by experience to develop flow sheet for reopening underground mine for operation and be able to carry out the complete engineering and preparation for installation of equipment and starting up, and, if qualified, to carry forward through process stages in milling. Salary, $8400 depending on qualifications. Location, Sierra county. S3802.

Recent Graduate Mining Engineer, with a degree in mining engineering or ore dressing, for a combination field and laboratory trouble shooting assignment in the wet processing phosphate rock operation. Location, South. W6655.

Mine Superintendent, with production and management experience in mining of uranium ore to take charge of 100-tpd operation at 50,000 to 100,000 tons proven property. Salary, $9000 per year plus living quarters. Location, Arizona. W6504.

Field Sales Engineer, degree in metallurgy or minerals beneficiation preferred, for multi-division company. Will be responsible for process equipment sales to the metallic and nonmetallic industries; must have three to five years experience in processing equipment field. Liberal benefits with good starting salary plus incentive based directly on sales efforts. Car furnished and expenses paid. Territory, northeastern area out of New York. W6330.

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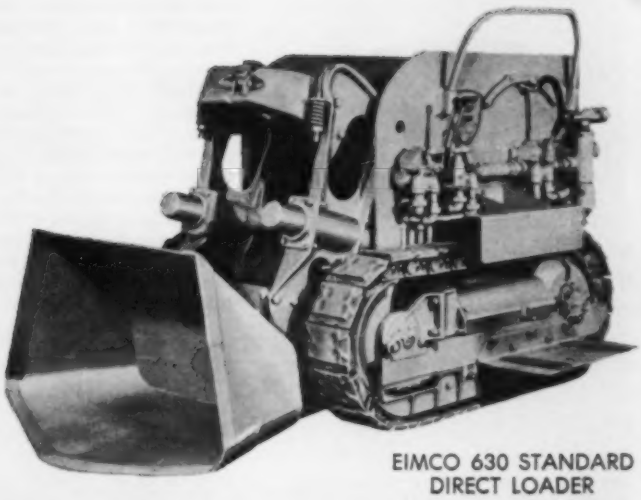

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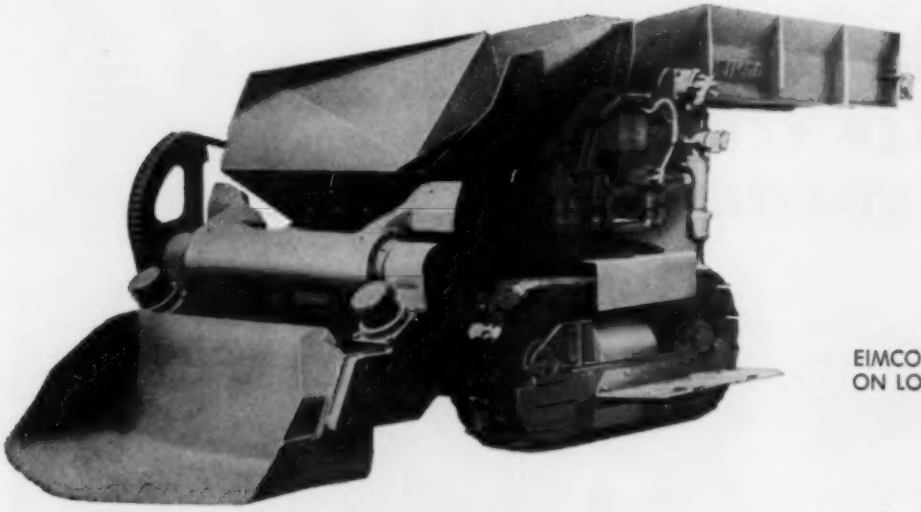

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Concise International Dictionary of Mechanics and Geology, English-French-German-Spanish, by S. A. Cooper, *Philosophical Library,* 15 E. 40th St., New York 16, N. Y., 408 pp., $6.00, 1958.—Purpose of this dictionary is to provide mechanics, engineers, and manufacturers with a handy volume in which they may find equivalents in the three main foreign languages—French, German, and Spanish, in addition to English—of the expressions and names of components most frequently occurring in their sphere of work. • • •

Beerman's All Mining Year Book, 1958-1959, *R. Beerman Publishers (Pty) Ltd.,* 76 Strand St., Capetown South Africa, over 400 pp., approx. $9.10, 1958.—South Africa is a world source of gold, uranium, and diamonds and has a potential source of practically all other minerals. This is the only book which covers mineral production in South Africa, and offers information on South West Africa, Bechuanaland, and Swaziland. • • •

Uranium Ore Processing, edited by J. W. Clegg and D. D. Foley, *Addison-Wesley Publishing Co. Inc.,* Reading, Mass., 450 pp., 118 illus., $7.50, 1958.—Here, for the first time in book form, is a condensed description of the latest details on all processes used in winning of uranium from its ores. The editors, both from Battelle Memorial Inst., have placed major emphasis on current practices in the U. S., but techniques in other countries also have been described. The most recent data (cutoff date is January 1958) on all methods now in use have been included. • • •

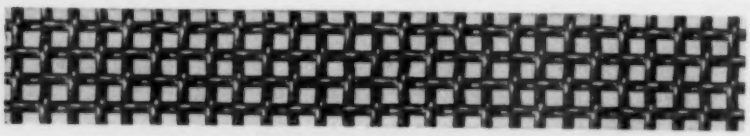
Minerals Yearbook, 1956, Vol. I, Metals and Minerals (except fuels), *U. S. Government Printing Office,* Superintendent of Documents, Washington 25, D. C., 1418 pp., $4.50, 1958.—Prepared by the staff of the Bureau of Mines Div. of Minerals, this volume includes chapters on metal and nonmetal mineral commodities, a review of these industries, a statistical summary, and chapters on mining technology, metallurgical technology, and employment and injuries.

Minerals Yearbook, 1956, Vol. III, Area Reports, *U. S. Government Printing Office,* Superintendent of Documents, Washington 25, D. C., 1300 pp., $4.25, 1958.—Prepared by the field staff of the Bureau of Mines, Regional Divs. of Mineral Industries, Vol III is comprised of chapters covering each of the 49 states, plus Hawaii, Puerto Rico, the Canal Zone, and other possessions, with a statistical summary and data on employment and injuries.

Minerals Yearbook, Vol. II, Fuels, 1954, 1955, 1956, *U. S. Government Printing Office,* Superintendent of Documents, Washington 25, D. C., 1954: 474 pp., $2.25, 1958; 1955: 448 pp., $2.25, 1958; 1956: 460 pp., $2.50, 1958.—Each volume includes chapters on mineral fuel, an employment and injury presentation, and statistical summary incorporating previous information. Also included in the 1955 and 1956 volumes are special review chapters with data on energy production and uses that have been included previously in the Bituminous-Coal chapter.

Recent Developments in Uranium Milling Technology, *Uranium Institute of America,* Uranium Center Bldg., Grand Junction, Colo., 108 pp., $5.00, 1957.—This is a transcript of the Mill Technology Symposium and addresses from the institute's annual

(*Continued on page 1222*)



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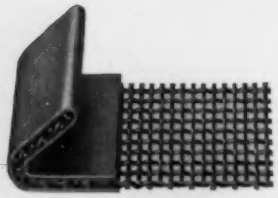

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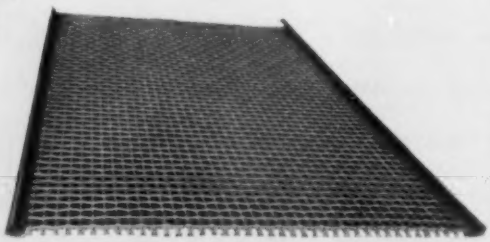

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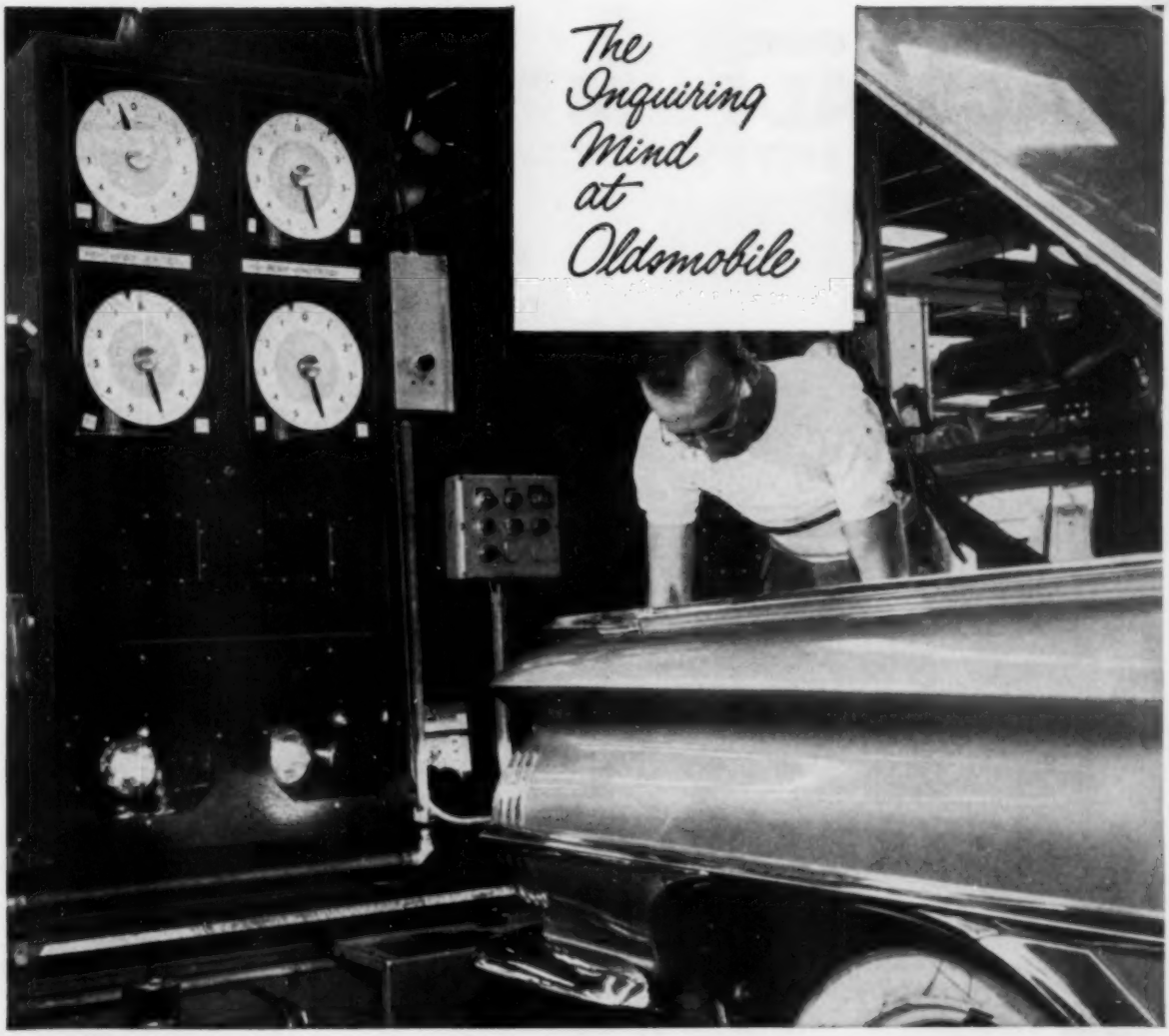

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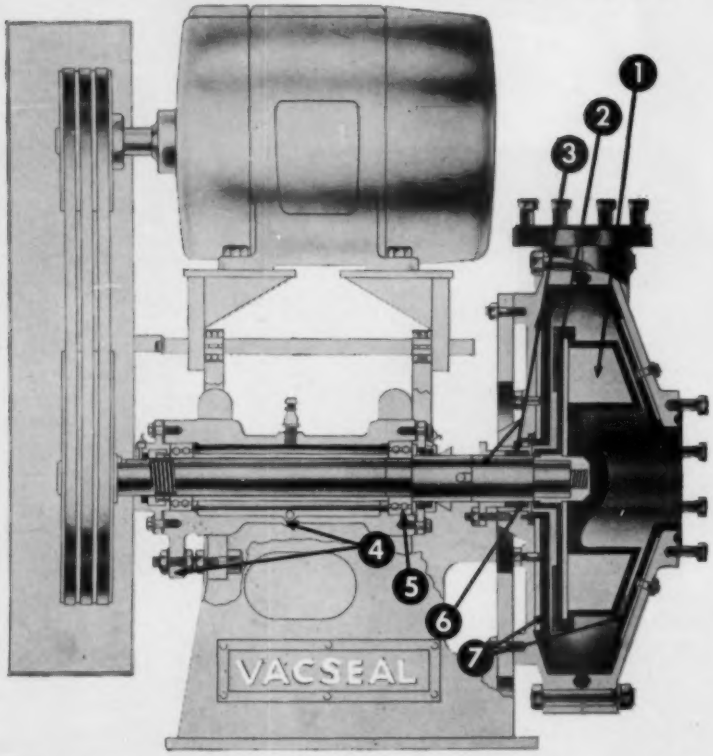

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BOOKS

(Continued from page 1220)

meeting held on May 17 and 18, 1957, at Denver. The subject matter covers new developments in the technology of extracting uranium from the various types and grades of ore that are now considered to be commercial or potentially commercial throughout the world. • • •

State Publications

Biostromes and Bioherms of the Onondaga Limestone in Eastern New York, by W. A. Oliver, Jr., Bulletin 45, *N. Y. State Education Dept., N. Y. State Museum,* Albany 1, N. Y., 23 pp., 1 plate, 3 figs., 50¢, 1956.

Guide to Nature and Environment of the Fossil Vertebrates of N. Y., by R. L. Moodie, Museum Handbook 12, *N. Y. State Education Dept., N. Y. State Museum,* Albany 1, N. Y., 45¢.

Geology and Ground Water in the Statesville Area, North Carolina, by Henry E. LeGrand, Bulletin 68, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., 50¢, 1954.

Ground-Water Resources in North Carolina, by H. E. LeGrand, Bulletin 69, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., gratis, 1956.

Upper Cretaceous Ostracoda from North Carolina, by Philip M. Brown, Bulletin 70, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., $1, 1957.

Lithium Resources of North Carolina, by S. D. Broadhurst, Information Circular 15, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., 25¢, 1956.

Geologic Map of North Carolina, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., color, 1:500,000, 1958.

Geologic Map of North Carolina, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., black and white, 1 in. equals 60 miles, no charge.

Geologic Map of the Coastal Plain of North Carolina, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., color, 1 in. equals 10 miles, 50¢.

Geologic Map of Virgilina District, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., color, 1 in. equals 1 mile, 50¢.

Map of North Carolina, *Dept. of Conservation and Development,* Mineral Resources Div., P.O. Box 2719, Raleigh, N. C., 1:500,000, 50¢.

The Geology of the Southern Part of Morton County, by Wilson M. Laird and R. H. Mitchell, Bulletin 14, *North Dakota Geological Survey,* State Geologist, Grand Forks, N. D., 3 maps, 42 pp., 7 figs., $1.00, reprinted 1958.

Geologic Report on Limestone Deposits in Stark County and Hettinger County, North Dakota, by Miller Hansen, Report of Investigation No. 8, *North Dakota Geological Survey,* State Geologist, Grand Forks, N. D., 33 pp., 24 figs., $1, reprinted 1958.

Guidebook of Glacial Geology of East-Central North Dakota, Miscellaneous Series No. 10, *North Dakota Geological Survey,* State Geologist, Grand Forks, N. D., 5 maps, $3, 1958.

29th Biennial Report, by Wilson M. Laird, *North Dakota Geological Survey,* State Geologist, Grand Forks, N. D., 24 pp., gratis, 1956.

Guide for Geologic Field Trip in Northeastern North Dakota, by W. M. Laird, Bulletin 30, *North Dakota Geological Survey,* State Geologist, Grand Forks, N. D., 25¢, 1956.

(Continued on page 1224)

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BOOKS

(Continued from page 1222)

The General Geology of Uranium in Southwestern North Dakota, by J. R. Bergstrom, RI 23, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 75¢, 1956.

Mississippian Stratigraphic Studies, Bottineau County, North Dakota, by Sidney Anderson and LaVerne Nelson, RI 24, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 4 maps, $1, 1956.

Geology of the Lower Pipestem Creek Area, North Dakota, by R. J. Kresl, RI 25, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 2 maps, tables, 75¢, 1956.

Geology of the Grassy Butte Area, McKenzie County, North Dakota, by E. G. Meldahl, RI 26, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1956.

Geology and Ground-Water Resources of the Hettinger Area, Adams County, North Dakota, by C. J. Rotinove, Ground Water Studies No. 24, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 44 pp., 2 plates, 2 figs., 4 tabs., 1956.

Geology and Ground-Water Resources of the Hankinson Area, Richland County, North Dakota, by John E. Powell, Ground Water Studies No. 25, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 45 pp., 4 plates, 4 figs., 3 tabs., 1956.

Geologic Map of North Dakota, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 1:1,000,000, 50¢, 1956.

Pre-Mesozoic Paleogeologic Map, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., $1, 1957.

Fuson Structure Map, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Pre-Cambrian Structure Map, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Structure Contour Map of Nesson Anticline, by A. F. Bateman, Jr., *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., $1.50, 1957.

Guidebook for Geologic Field Trip in the Valley City Area, North Dakota, Miscellaneous Contributions No. 1, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for Geologic Field Trip in the Minot Area, North Dakota, Miscellaneous Contributions No. 2, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for Geologic Field Trip in the Devils Lake Area, North Dakota, Miscellaneous Contributions No. 3, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for Geologic Field Trip in the Bismarck-Mandan Area, North Dakota, Miscellaneous Contributions No. 4, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for the Dickinson Area, North Dakota, Miscellaneous Contributions No. 5, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for the Williston Area, North Dakota, Miscellaneous Contributions No. 6, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook for the Jamestown Area, North Dakota, Miscellaneous Contributions No. 7, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook from Fargo to Valley City, Miscellaneous Contributions No. 8, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

Guidebook from Grand Forks to Park River, Miscellaneous Contributions No. 9, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 50¢, 1957.

The Economic Geology of Crawford, Marion, Morrow, and Wynadot Counties, by J. F. Hall and R. L. Alkire, RI 28, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 43 pp., 11 figs., 9 tabs., $1, 1956.

Gravity Survey of the State of Ohio, by W. A. Heiskanen and U. S. Uotila, RI 30, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 34 pp., 8 figs., 1 tab., 2 maps, $1, 1956.

Handbook for Teachers of Earth Science, by Mildred F. Marple and W. C. Brown, IC 15, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10. Ohio, 61 pp., 6 figs., 15 plates, 50¢, 1958.

Geology Along Route 40 in Ohio, by Pauline Smyth IC 16, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 65 pp., 9 figs., 24 plates, maps, 25¢, 1957.

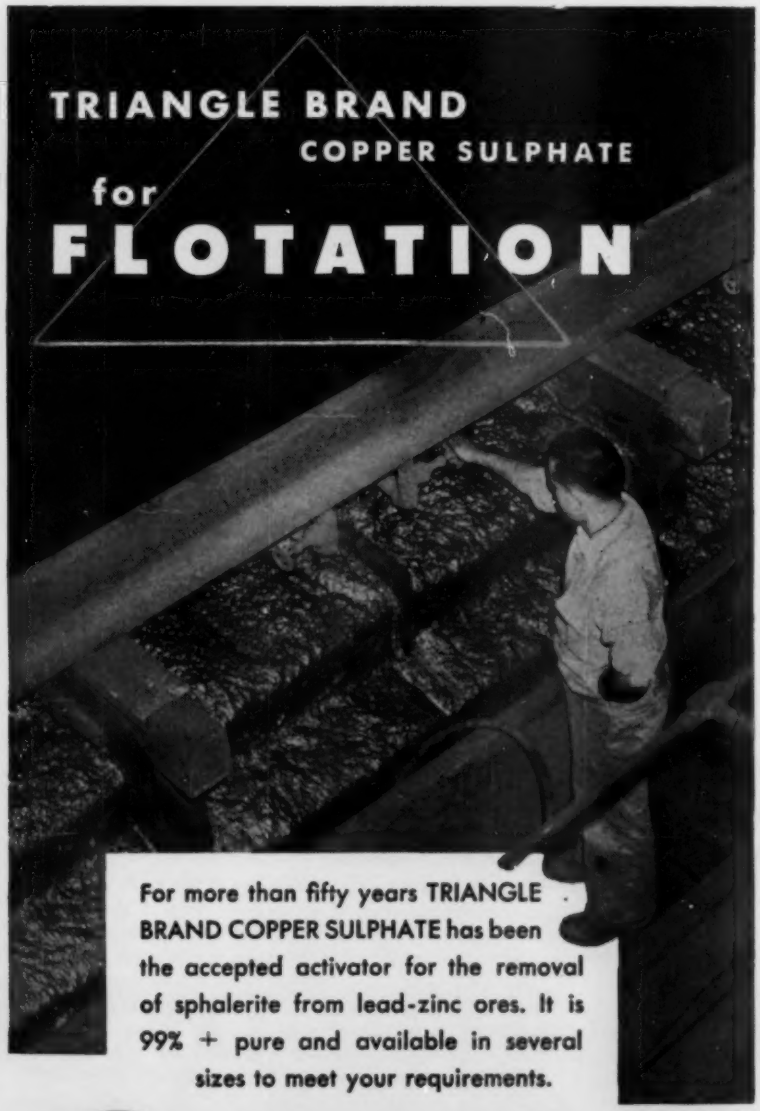
An Application of Business Machine Technique to Stratigraphy and Coal Resources Studies, by W. H. Smith, R. A. Brant, and Marian S. Klein, IC 18, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 10 figs., 26 pp., 25¢, 1956.

The Search For Uranium, by C. A. Lamey; and **Prospecting for Uranium in Ohio**, by K. V. Hoover, Educational Leaflet Series 1, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 10 pp., 1 fig., map, 1956.

Mineral Industries Map of Ohio, 1956, by R. W. Smith, Map No. 3, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, plus a directory of producing firms, if requested, free, 1956.

Chart of Bituminous Coal Production in Ohio by County 1800-1955, by Marion S. Klein, Chart No. 1, *Div. of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 15x30 in. gratis, 1956.

(Continued on page 1226)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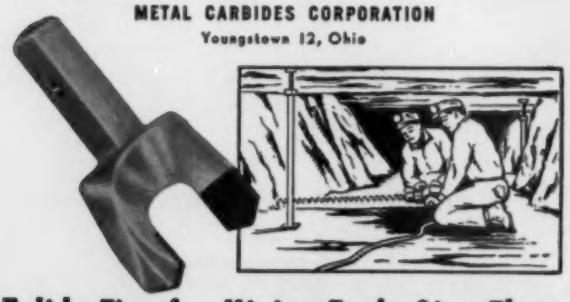

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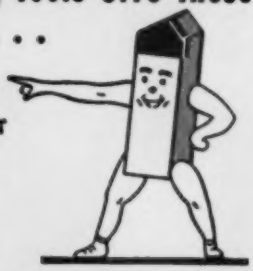

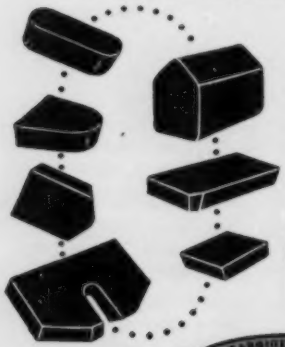

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BOOKS

(Continued from page 1224)

Canadian Publications

R 17 Research Report, Voltaic Cells in Fused Salts, Part 2, by S. N. Flengas and T. R. Ingraham, *Publications Distribution Office*, Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Can., 25¢ (make payment to Receiver General of Canada), 1958.

R 1 Research Report, Some Effects Of Pressure on Consumable Electrode Arc Melting, by J. W. Suiter, *Publications Distribution Office*. Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Canada, 25¢ (make payment to Receiver General of Canada), 1958.

R 20 Research Report, Voltaic Cells in Fused Salts, Part 4, by S. N. Flengas and T. R. Ingraham, *Publications Distribution Office*, Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Canada, 25¢ (make payment to Receiver General of Canada), 1958.

Coaticook Malvina Area, electoral districts of Stanstead and Compton, G. R. No. 69, by H. C. Cooke, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Southwest Part of Lesueur Township, electoral district of Abitibi-East, G. R. No. 72, by R. Bruce Graham, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Beetz Lake Area, electoral district of Saguenay, G. R. No. 73, by P. E. Grenier, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Johan Beetz Area, electoral district of Saguenay, G. R. No. 74, by Gerald E. Cooper, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Northern Quebec, G. R. No. 75, by J. E. Gilbert and R. Bergeron, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

St. Magloire and Rocsaire-St. Pamphile Areas, G. R. No. 76, by Jacques Beland, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Duquet Area, Mistassini Territory, P. R. No. 331, by A. N. Deland, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Doncaster Area, electoral districts of Terrebonne and Montcalm, P. R. No. 335, by M. A. Klugman, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Woburn Area, electoral district of Frontenac, P. R. No. 336, by R. A. Marleau, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Guercheville-Lapparent Area, P. R. No. 343, by Jerome H. Remick, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

St. Etienne de Bolton Area, P. R. No. 344, by H. de Romer, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Hainaut-Champagne Area, P. R. No. 345, by H. B. Lyall, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Thorne-Leslie-Clapham Area, P. R. No. 346, by Ralph Kretz, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

St. Sylvestre Area, P. R. No. 347, by F. W. Benoit, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

Brochant-De Bonnard Area, New Quebec, P. R. No. 348, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1957.

St. Sylvestre—St. Joseph Areas, Electoral Districts of Megantic, Lotbiniere, Dorchester and Beauce, P. R. No. 359, by F. W. Benoit, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1958.

Lead and Zinc Deposits of the Province of Quebec, P. R. No. 371, by G. S. Sater, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1958.

Marin-Picquet Area, Abitibi-East Electoral District, P. R. No. 361, by Jerome H. Remick, *Dept. of Mines*, Hotel Du Government, Quebec, Canada, 1958.

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Notes on Potash Production by *J. Marshall Downey*—Sources, mining and beneficiation of potash and the production of potash products are outlined. Recent economic trends are summarized and predictions for industry future are made. **Ref.: MINING ENGINEERING, December 1958, pp. 1253-1256.**

Current Prospects for Competitive Nuclear Power by *Karl Cohen*—The question of attaining competitive nuclear electric power is of interest to uranium producers because the rate of attainment of this goal determines the date when there will be a solid, domestic, nonpolitical uranium market. A three-pronged attack on costs involves technological advances, higher rate of specific power extraction from equipment, and standardization of products and increasing manufacturing volume. **Ref.: MINING ENGINEERING, December 1958, pp. 1257-1258.**

Minerals for Insecticide Formulations by *Henry T. Muiryan*—Since World War II, U. S. chemical companies have loosed a flood of synthetic organic insecticides. These synthetics fall into two broad categories. DDT is the best known of the chlorinated hydrocarbons and Parathion is the most famous (or infamous) of the organic phosphate *nerve gas* type. Production and composition of various compounds are considered. **Ref.: MINING ENGINEERING, December 1958, pp. 1259-1260.**

Advances in Magnetic Separation of Ores by *L. A. Roe* (TP 4781B)—Magnetic separation of iron ores is one of the fastest growing segments of the minerals beneficiation industry. The tonnage of taconite ores processed annually by magnetic separation methods will, in a few years, reach 100 million. The developments of various types of magnetic separation (such as dry and wet) are outlined and application to specific ores at various plants is covered. **Ref.: (MINING ENGINEERING December 1958) AIME Trans., 1958, vol. 211, pp. 1261-1265.**

Lucky Friday Mine: History, Geology, and Development by *William T. Folwell* (TP 4780A)—The Lucky Friday mine east of Mullan, Idaho, is an outstanding example of a property in the Coeur d'Alene district where a small and insignificant-appearing Ag-Pb-Zn vein at the surface has changed at depth into a large vein of great importance. The vein has little surface expression and above the 1200 level the ore shoots are small and discontinuous. Between the 1200 and 2450 levels the main ore shoot has shown remarkable improvement on each succeeding lower level and today the mine is one of the major Pb-Ag producers in the district. Ore reserves have been estimated to provide 19.2 years of operation beyond February 1958, based on the average yearly production of 40,000 tons maintained at the present time. **Ref.: (MINING ENGINEERING, November 1958) AIME Trans., 1958, vol. 211, pp. 1266-1268.**

Magnetic Separation for Mesabi Magnetite Taconite by *J. E. Forciea, L. G. Henrickson,* and *O. E. Palasvirta* (TP 4777B)—Magnetic separation was first applied commercially in 1922 to beneficiate Mesabi Range taconite at Babbitt, Minn. After considerable pilot plant investigations, two commercial taconite plants were constructed; the E. W. Davis Works of Reserve Mining Co., with a nominal capacity of 3.75 million tons of pellets per year, got under way in 1955, and Erie's 7.5 million ton plant began operation two years later. Beneficiation techniques at both plants are described in detail. **Ref.: (MINING ENGINEERING, November 1958) AIME Trans., 1958, vol. 211, pp. 1269-1276.**

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available only if followed by a preprint order number. These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N. Y.*

Recent St. Joe Milling Advancements In Southeast Missouri by *H. A. Hoffman*—Six mills are operated in Missouri by the St. Joseph Lead Co. Some of the major improvements made in one or more of the mills during recent years are: installation of Symons cone crushers as secondary crushing units; replacement of rolls with Allis-Chalmers rod mills in grinding circuit; mechanical flotation cells as replacements for St. Joe pneumatic machines; improvements in mill water systems; spiral classifier installation for dewatering table tailing; improved tailing disposal; recovery of zinc; use of cyclones for dewatering, desliming and tailing disposal; all-float milling; experimental work on concrete pump wearing parts; linatex conveyor belt coverings; polyethylene filter bags and cloth; remilling of old tailing. *Mid-America Minerals Conference, October 1958.*

Cyanide Leaching to Remove Copper From Zinc Concentrates by *Norman Hedley and Howard Tabachnick*—Leaching with cyanide solution has been found effective in reducing the copper content of a zinc concentrate from 0.05 pct down to the desired specification of less than 0.02 pct. Solution strength was 0.25 pct NaCN equivalent and time of leaching 15 min. 88 pct of the cyanide added was regenerated. The spent solution containing copper can replace some of the copper sulfate used for sphalerite activation. Net reagent consumption was 0.60 lbs of NaCN equivalent and 5 lb of H_2SO_4 per ton of concentrate treated. *Mid-America Minerals Conference, October 1958.*

Scope of Ore Dressing Microscopy by *G. C. Amstutz*—An attempt is made to list and discuss systematically all the possible mineralogic factors which may influence the methods and grades of mineral concentration. Special emphasis is placed on locking types, and a new classification of locking types is presented and its usefulness and limitations are discussed and illustrated. *Mid-America Minerals Conference, October 1958.*

Modifications In the White Pine Mill Flow Sheet Through Installation of Two-Stage Cyclones by *Virgil Lessels*—Paper outlines the original White Pine flow sheet, placing the desliming of primary flotation tailings in the circuit. The area of possible improvement was removal and discard of slimes containing less copper; the removal for regrinding of the largest size particles from feed to secondary flotation.

The circuit chosen was a two-stage cyclone removing as first stage overflow an improved slime for discard, as second stage overflow the medium-sized material for secondary flotation, and as second stage underflow a varying amount of the coarsest grains for immediate regrinding for liberation of copper. Some modification of flotation practice was indicated in order to take fullest advantage of the superior classification obtained. *Mid-America Minerals Conference, October 1958.*

Iron in Missouri by *John S. Brown*—Aerial magnetometer surveys in southwestern Missouri in the past ten years have confirmed several previously known magnetic anomalies and have uncovered a few others, notably that at Pea Ridge where an iron deposit of considerable size has been discovered and is under joint development by St. Joseph Lead and Bethlehem Steel Cos. This paper deals with the history of these developments including some general data on the ore occurrence at Pea Ridge. *Mid-America Minerals Conference, October 1958.*

Kentucky Fluorspar District: Its Geology and Exploration by *John S. Tibbs*—A review of the basic geology associated with the deposition of fluorspar in the west Kentucky fluorspar field and an outline of a workable field procedure for finding ore reserves in that area. *Mid-America Minerals Conference, October 1958.*

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ANDREW FLETCHER, NEW PRESIDENT OF UET, TO PUSH DRIVE FOR COMPLETION OF UNITED ENGINEERING CENTER

Andrew Fletcher, president of the St. Joseph Lead Co., has assumed the additional responsibilities of president of United Engineering Trustees Inc.

Founded in 1904 to advance the engineering arts and sciences, the United Engineering Trustees Inc. represents the five professional societies of the major engineering branches with three board members from each. The Corporation directs the research programs of the Engineering Foundation as well as many other joint activities.

Mr. Fletcher is a Past-President of AIME and was awarded the Charles F. Rand Gold Medal in 1957 for "distinguished administration in non-ferrous mining and metallurgical enterprises." He is also chairman of the Industrial Hygiene Foundation of America, vice president and treasurer of the American Mining Congress, and past-president of Lead Industries Assn.

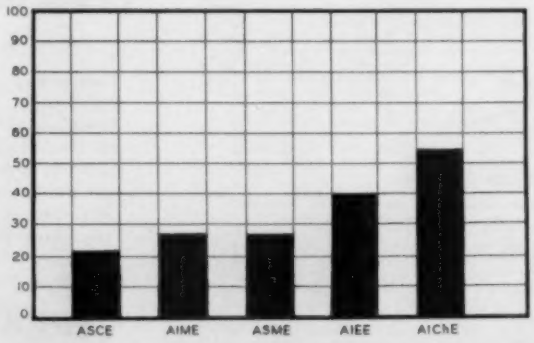
Mr. Fletcher's acceptance of the presidency of United Engineering Trustees Inc. is in accord with his belief in public service, as is evidenced by his activities in his home community of Mendham, N. J., where he is a member of the Council, trustee of the Library, and trustee of the Presbyterian Church. He attended the Hill School in Pottstown, Pa., and graduated from the Sheffield Scientific School, Yale University, in 1916. Since that time he has received three honorary degrees in engineering and law.

After a year in the Harlan and Hollingsworth shipyard at Wilmington, Del., as a mechanic, Mr. Fletcher went to Baltimore as a foreman for the Baltimore Dry Dock Co. In 1918 he became secretary of the W. & A. Fletcher Co., Hoboken, N. J., and in 1924 was in direct charge of the business until the shipyard was sold to the United Dry Docks Inc. In 1929 he gave up his connection with the shipbuilding industry to become vice president and treasurer of St. Joseph Lead Co. He became executive vice president in 1946 and president in 1947.

Recent architectural study of the proposed building.

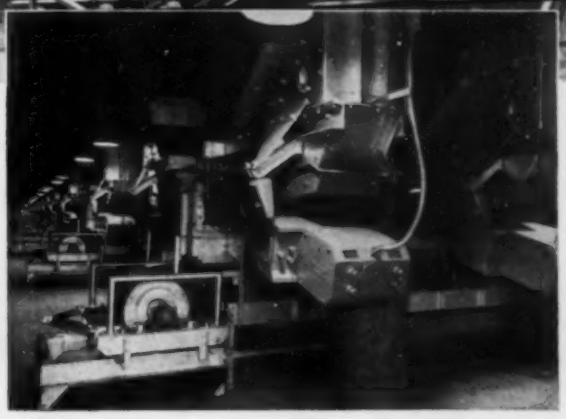
United Engineering Trustees Inc. has purchased the block front between 47th and 48th Sts. on the United Nations Plaza for the construction of a 20-story Engineering Center, the cost of which is roughly estimated at $10,000,000. Their present home on west 39th St. will be sold. The Engineering Societies Library will move into the new Center where it will be able to expand the services that have already made it one of the finest public engineering libraries in the country.

In order to bring the benefits of centralized activities in the new Engineering Center to as widespread a group of engineers as possible, the five societies have extended invitations to other engineering societies to unite with them in using the new facilities as their headquarters. Thoroughly modern in every respect, the new Center will include, in addition to the headquarters office space for each group, such facilities as a cafeteria, dining rooms, meeting rooms, and a large memorial hall, suitable for group meetings or for major exhibitions of technical progress. Few, if any, societies or groups in the world will then possess headquarters as impressive in appearance and as efficient in operation as the engineers.



Percentage of progress toward their goals made by the five Societies in the Members Gifts Campaign for the new United Engineering Center. The data as of November 14.

Jeffrey magnetic separators help raise iron content of pellets to 64%.



Jeffrey vibrating feeders keep ore on the move.

New Taconite Plant sets 24-hour, year-round pace!

IRON YIELD of the Mesabi Range is being greatly extended by a new plant which can, *every day*, turn about 63,000 long tons of taconite ore into approximately 20,000 tons of pellets bearing up to 64% iron. Efficient, trouble-free Jeffrey equipment is an important part of the vast and highly mechanized operation which makes this processing economically practical.

Jeffrey Magnetic Separators – 216 ball mill roughers and finishing separators are used in concentrator operations. After proper settings are made, feed may vary from zero to maximum capacity without further adjustment. Separators furnished in both permanent and electro types.

Jeffrey Vibrating Feeders – 48 heavy duty 5DTS units feed coarse ore from surge bins to cone crushers and screens. 324 Type 4DTH units feed fine ore to rod mills. 48 Type 4DTS feeders handle hot pellets. Balanced vibration assures quiet operation, definite control, easier installation, low operating and maintenance costs.

In all types of mining and processing of solids, carefully engineered, precision built Jeffrey machinery and components provide long, dependable service. Write for Catalog 910. The Jeffrey Manufacturing Company, 865 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

RIPPING DIGGING

This CAT No. 977 Traxcavator increased production 30%

Dixie Mines, Inc., one of the nation's largest producers of hi-grade mica, was using a competitive machine until last year in one of their mines. This mine, near Heflin, Alabama, is under the direct operating supervision of the firm of Bailey and Van Horn. Then a Caterpillar No. 977 Traxcavator with No. 6 Ripper was put to work. Result:

"By using the No. 977 we have upped our production 30%," says Joe W. Bailey, resident manager. "It loads faster, lifts faster and is mobile. Besides working the overburden and the mica bearing pegmatite, we use it to feed the mill at night, build dams, maintain roads and many other jobs. It's a good all-around machine—and we're happy with the freedom from down time and low cost of operation."

The No. 977 rips the tough pegmatite then loads it into trucks. During a ten-hour day, production averages 500 cu. yd. The material is put through a jaw crusher, washed and screened, leaving a concentrate of mica as residue.

The No. 977 works at such a money-making pace because it's built from the ground up as a loader-excavator, not just a tractor with bucket attached. About 26 sq. ft. of ground-gripping track provide tremendous traction to crowd the 2¼-yd. bucket full every time, get away fast.

In addition, operator comfort means that this fast pace is maintained. He has a high seat with excellent visibility of all bucket positions. Controls are easily reached—bucket control a one-hand operation.

Your Caterpillar Dealer has three sizes of Traxcavators in his line. Get the full story on them today. Have him demonstrate on your job. Count on him for fast service and quality Caterpillar parts.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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THE NO. 977—POWER AND VERSATILITY FOR MINING

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

Overlap Bottom Dump

Sanford-Day Iron Works Inc. has combined its overlapping end design mine car and one-door bottom dump type car into a single automatic unit featuring high capacity, clean shedding, and prevention of spillage. **Circle No. 1.**

Small Cryderman Mucker

Shaft & Development Machines Inc. has developed a small version of its standard Cryderman shaft mucker that will operate in circular shafts of 6 to 10-ft diam. With a full view of shaft bottom, operator can move unit's boom 12 ft forward, 6 ft back, and 12 ft to either side of vertical. Overall length is 24 ft 9 in. **Circle No. 2.**

Horizontal Hole AN Blasting

Atlas Powder Co. has developed a blower unit to mechanize the loading of ammonium nitrate into blast holes. Designated Jetloder, the machine uses compressed air to load both blasting agent and sand stemming. Tests have shown it can load a 50 to 60-ft horizontal hole at the rate of 2½ lb per second using an AN-diesel fuel mix. Excellent density and high fragmentation have resulted and recent experiments seem

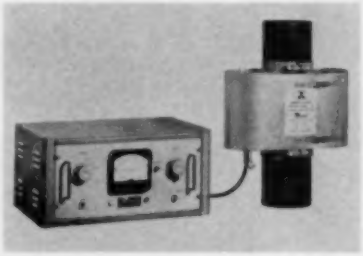
to indicate a 1¼-in. diam continuous primer of special gelatin can be used for detonation with this method. **Circle No. 3.**

Belt Conveyor Scale

Weighing & Control Components Inc. has developed a unitized, pneumatic, belt conveyor scale which quickly installs on existing units—fixed or variable speed. Frame arrangement eliminates effects of side thrust. **Circle No. 4.**

Slurry Control

A nuclear density gage developed by *Bendix Aviation Corp.* will give accurate and continuous measurement of the specific gravity or percent solids content of ore thickener underflow. Yield can be increased because the process can be operated continuously at the optimum control point. Sensing head (see below, right) is clamped externally to existing pipe. Amplifier and recorder/controller can be mounted 1000 ft or more from the sensing head. **Circle No. 5.**



Remote Continuous Coal Miner

Joy Mfg. Co. and *Union Carbide Corp.* have signed an agreement that gives Joy manufacturing and sales rights to a remotely controlled continuous mining system first developed by Union Carbide Olefins Co. The system is operated by a man at an electronic control center, actuating a mining machine which can penetrate high-wall coal to a depth of 1000 ft or more. The mining unit reports electronically if it is heading properly into coal so that the operator can guide its course to follow the seam. A prototype miner has shown ability to advance more than 100 ft per hr. A heavy-duty transport system follows the mining unit, delivering material to an outside discharge station. **Circle No. 6.**

Conveyor Idlers

Transall Inc. uses a lithium base lubricant in its belt conveyor idlers that causes no trouble in cold or heat and will not oxidize metal parts over long use. The prelubricated idlers are equipped with interchangeable welded steel rolls. **Circle No. 7.**

Rotary Drill

Robbins Machine & Mfg. Co. has announced the new Robbins RR10 rotary drill for use with crawler tractors in drilling large blast holes. Up to 60,000 lb bit pressure, heavy duty drive give superior performance in drilling holes 6⅝ to 10⅝ in. diam. Unit can be field mounted. **Circle No. 8.**

Electrostatic Separator

The E-Machine, developed by *General Mills*, is a new electrostatic device originally intended for use in

flour milling but found capable of isolating metallic aluminum from its oxide and sorting titanium minerals from sand. Material is fed to conducting deck where it accepts an electrostatic charge. If this charge is strongly opposite that of a charged trough above the deck, the particles bound upward into the trough and are thus separated. A commercial version employs seven decks. **Circle No. 9.**

Underground Truck

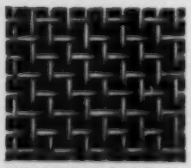
Ortruc Inc. has developed the Oremaster Utili-Truck for use underground as a personnel truck, parts or tool carrier, or as a special lubrication vehicle. Equipped with power take-off, the vehicle is available in ¾ to 2-ton sizes and choice of 2 or 4-wheel drives. **Circle No. 10.**

News & Notes

Gardner-Denver Co. has started forging operations at its new No. 2 Denver plant. The company also announces plans for acquiring Mayhew Machine Co. and Mayhew Supply Co., both of Dallas. Mayhew is top producer of seismograph and geophysical drilling equipment for oil industry and also makes rotary drilling equipment for mining and construction . . . . Thompson Products Inc. and Ramo-Wooldridge Corp. have merged to form *Thompson Ramo Wooldridge Inc.*

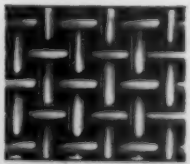
for high throughput or long life

Throughput and wear-resistance are two important factors that affect your choice of screening. And the one that is more important to you will determine the type of screening you choose: light wire screens with a large percentage of open area that produce higher tonnage per hour . . . heavy-wire, slow screening that lasts longer, minimizes downtime . . . or medium wire screens that combine some of the features of each.



Effective Open Area 60%—
Fast Screening—Short Life

(Both screens have same size openings.)



Effective Open Area 30%—
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But whatever your screening problem—whether you need longer life for hard, extremely abrasive materials, or higher volume on standard jobs—there's a CF&I Screen that's right for you. CF&I offers a choice of:

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Specifications: Complete range from .035" to 1" diameter wire size; from .063" to 6" clear opening.

In addition, all CF&I Industrial Screens are made from top quality carbon or alloy steel wire. Quality is carefully controlled from blast furnace to wire drawing and weaving operations, to ensure maximum resistance to abrasion, vibration and fatigue.

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CF&I OFFICES IN CANADA: Montreal • Toronto • CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

FREE LITERATURE

(21) SOIL SAMPLING PROCEDURES: A book on the basics of soil sampling—usual cost is $1—is offered free to readers by *Acker Drill Co. Inc.* The highly-detailed 68-page manual covers three major sections: preliminary or general survey sampling, detailed explorations, and logs and records.

(22) MOTION INDICATOR: *Bin-Dicator Co.* will supply information on a new low-cost motion indicator designed primarily for the process industries. This new protective device, called Roto-Guard, is a means of converting motion of various types into a signal which may be used to energize an alarm system.

(23) ROTARY POSITIVE BLOWERS: *Roots-Connersville Blower*, Div. of Dresser Industries Inc., presents an 8-page bulletin, AF-258, that covers R-C type AF rotary positive blowers, including new capacities and pressure ratings. Detailed design and construction information is included.

(24) OVERLAPPING END CARS: *Sanford-Day Co.* offers a folder illustrating their overlapping end cars which make loading automatic with maximum haulage safety and one-man automatic dumping.

(25) CRUSHERS: *Morse Bros. Machinery Co.* has an informative brochure on its laboratory machinery, jaw crushers, and pulverizers. It details laboratory belt feeders, sample grinders, classifiers, and the continuous ball mill.

(26) TRACTORS: *John Deere* model 440 industrial wheel-type tractor is featured on a bulletin detailing its forward-swept grille, rugged construction, modern design. A graph pictures performance, specifications are listed clearly.

(27) VALVES: A condensed version of *Ohio Injector Co.'s* valve catalog lists its complete line with graphs of specifications.

(28) WOOD TANKS: *Fluor Products Co.* has published a reference and data handbook illustrating why wood tanks have advantages over other storage tanks that are affected by heat, water, or corrosive fumes. Tank capacities, physical properties, and chemical components are detailed in this 28-page booklet.

(29) DENSITY MEASUREMENT SYSTEMS: *Industrial Nucleonics Corp.* offers a graphic explanation of the AccuRay density measurement system in bulletin NI-158. The system is based on the variation in ability of materials to absorb radiation. Method permits continuous measurement of specific gravity, percent solids, concentration, or related quantity.

(30) HAMMERMILLS: *Hammermills Inc.* has published a pamphlet describing impactor-type and regular hammermills that feature non-clogging moving breaker plates and reversible center feed.

(31) CRADLE IDLER: *McNally Pittsburgh Mfg. Corp.* bulletin 458 gives complete information on the new cradle idler and belt conveyor, with photographs, dimension drawings, and capacity tables. Featured are data covering underground material handling by belt conveyor.

(32) SELF-LOADING TRANSPORT: The *Sanford-Day* Gismo is dramatically illustrated in bulletin B100 with photographs of the mucking machine in operation. Gismo requires less capitalization, fewer men, and no sychronizing of several machines to get out tonnage.

(33) DESIGNING IN 3-D: *Scott Industries Inc.* has released a catalog which describes thousands of parts and materials used in building industrial scale models. With these parts the average draftsman can build realistic miniatures of industrial plant layouts, interconnecting piping or wiring, lever systems, etc. Valuable time can be saved and problems solved by this do-it-yourself technique.

(34) MOTORS: A 27-page booklet covering synchronous motors and controls is now available from *Westinghouse Electric Corp.* Completely illustrated, the brochure contains motor selector charts, application data, and formulas for calculating power factor. A quick summary of types and features is offered in this booklet, B-7292.

(35) STRIP MINING EQUIPMENT: "Strip Mining Report" by *Caterpillar Tractor Co.* shows equipment to help the coal stripper reduce production costs. Time and cost savings resulting from seam breaking with the Cat D9 tractor and Kelley coal ripper are explained.

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12

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after March 15, 1959—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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61	62	63	64						

Students should write direct to manufacturer.

(36) PUMPS: *Galigher Co.* offers information on Vacseal pumps for use at uranium mills where corrosive or abrasive materials, slurries, and acid solutions must be handled. A map of the mills that now use these sturdy pumps shows widespread success of the Galigher product.

(37) GRINDING PLANT: A new bulletin by *Allis-Chalmers Mfg. Co.* describes a grinding plant that features a vibrating grinding mill. This small, economical, high-capacity mill requires less than half the space needed by similar equipment and costs 25 pct less. Bulletin 07B7138 lists the specifications.

(38) LOADER: *J. I. Case Co.* Terra-Trac crawler-mounted loader model 320 is outlined in a folder which checks exclusive advantages of this low-priced machine. It has knock-out dumping action, improved steering, and a hydraulically-operated scarifier.

(39) FLEXIBLE CORDS: *Okonite Co.* has published bulletin 1108 with 64 pages of data detailing a line of mold-cured Okoprene (neoprene) sheathed cords and cables. These Okocord constructions can provide answers to wiring problems.

(40) COAL BREAKERS: *McNally Pittsburgh Mfg. Co.'s* new bulletin 658 gives latest descriptive data on coal breakers and crushers, including capacities, sizes, and dimensional drawings of a variety of units.

(41) LIFT TRUCK: *Allis-Chalmers Mfg. Co.* illustrates engineering, design, and construction of the recently introduced FT20-24, 2000-lb capacity lift truck in an 8-page catalog (BU-485) that is now available.

(42) TRACTORS: New features of *Caterpillar Tractor Co.* DW21 and DW20 wheel tractors are highlighted in a recently-released brochure. The Super Turbo engine and Torsionflex seat are illustrated, as well as a new pressure ratio control system.

(43) WEIGHING & FILLING MACHINE: *Richardson Scale Co.* offers information on the Holm model SS automatic weighing and filling machine for production packaging of free and non-free flowing materials. Bulletin H-1 tells how this bench model machine will increase efficiency.

(44) PROCESS CONTROL: A newly improved instrument for continuous measurement of one gas in multi-component mixtures is pictured in bulletin 0716-2, released by *Mine Safety Appliances Co.* The M-S-A Gas Thermatron uses two different types of cells employing identical filaments to measure the complex mixture. Applications to a variety of gas analysis problems are suggested.

(45) UTILITY TRACTORS: *Allis-Chalmers Mfg. Co.* has published a new brochure on model D-14 and D-17 tractors to show the many uses of these versatile units.

(46) POWER TOOLS: *Syntron Co.* announces publication of a new 4-page catalog on portable power tools. Complete data and specifications for electromagnetic electric hammers and hammer drills, electric saws, gasoline hammer paving breakers and rock drills, and concrete working tools are included.

(47) PORTABLE BINS: *Pioneer Engineering Co.* offers a sales folder describing a new line of portable bin units intended to increase plant output. The basic unit stores 6 cu yd of material, extensions are available.

(48) STUDY OF LUBRICANTS: Lubrication Newsletter No. 5, a technical paper covering the effect of lubricants on the wear in of new machinery, has been released by *Alpha-Molykote Corp.* A thorough engineering study of the surface geometry of mating surfaces is included, together with a discussion of Coulomb's theory on friction as it applies to asperities on machined surfaces.

(49) TRACTOR SHOVEL: *Yale & Towne Mfg. Co.* has published a 20-page brochure on its Y-18 industrial tractor shovel which is designed to perform 25 pct more work than comparable models. Features are discussed in detail and included is a reference list of the Yale lines of industrial lift trucks and hoists.

(50) BORING BAR: *Kennedy Van Saun Mfg. and Eng. Corp.* describes a new and effective device for removal of rings formed during nodulizing and similar kiln operations. The boring bar operates without interruption of the kiln operation, according to bulletin 58-B.

(51) JAW CRUSHER: A new 16-page jaw crusher catalog published by *Rogers Iron Works Co.* details 13 crusher sizes for heavy duty and seven sizes in a roadbuilder series. Dimensional drawings and capacity tables are supplied.

(52) SAFETY GOGGLE: *American Optical Co.* announces a new safety goggle for protection against splash, spray, and impact exposure. Indirectly ventilated, the goggle is valuable in humid conditions for the chemical industry. For details see bulletin S-6811.

(53) ORE-WEIGHING SYSTEM: *Richardson Scale Co.* has issued information on a new ore-weighing system that weighs, records, and prints production capacities of up to 200 tph. A duplex suspension hopper scale and totalizer printer comprise the system.

(54) TIME-LIMITING BLASTING SWITCH: *Atlas Powder Co.* says improved timing accuracy of delay electric blasting caps connected in parallel circuits can be achieved with the Atlas Arcmaster blasting switch. Switch avoids arcing in long-period delay blasting by limiting application of current to the blasting circuit to .025 to .030 sec. Arcmaster was designed primarily for tunnel work, but should be useful in all parallel circuit standard delay blasting in improving timing and reducing misfires.

(55) INDUSTRIAL EQUIPMENT: A comprehensive catalog of industrial equipment has been published by *Massey-Ferguson Industrial.* Featured is the Work Bull 202 industrial tractor equipped with auxiliary attachments. Power-matched equipment gives top efficiency.

(56) CRANE: Rubber-mounted cranes are described in a bulletin by *Koehring Co.* The models are convertible for dragline, clamshell, or bucket work.

(57) DUST COLLECTION: *Ducon Co. Inc.* announces availability of the type G rotary discharge gate for dust collection, pneumatic conveying, and feeding applications. Four gate styles are available.

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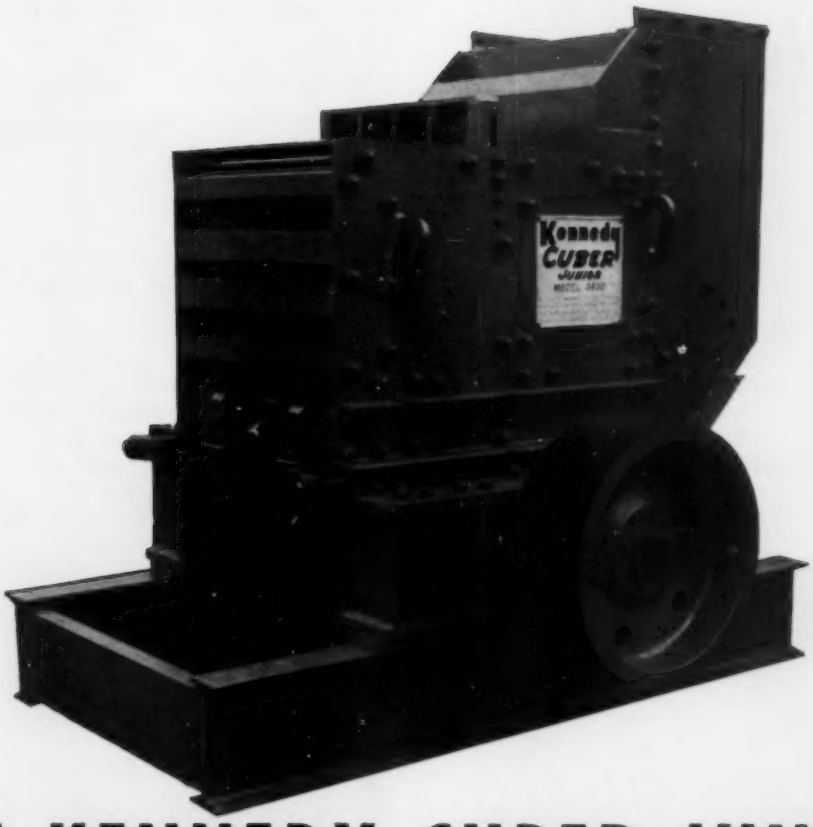


THE KENNEDY CUBER JUNIOR

The ONLY Small Impact Breaker with the Massive Construction of a Dual Rotor Impactor

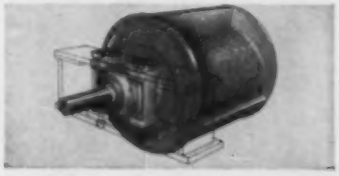
For high tonnage, high ratio of reduction, low cost, and an absolute minimum of flats, the husky, single rotor, 75 to 150 horsepower KENNEDY Cuber Junior answers a vital need. The same exclusive KENNEDY rotor which has been so successful and so economical in the Cuber Senior is responsible for the high performance of the KENNEDY Cuber Junior.

The KENNEDY Cuber Junior

- combines primary and secondary reduction in one operation . . . reduces the number of machines required because of its high capacity. *The result* —marked savings in capital investment.
- shatters rock along the lines of natural cleavage . . . operates on the principle of true, controlled free impact. *The result*—maximum useful output of evenly graded, cubical product.
- is the easiest impact breaker to maintain . . . output and product quality are kept high with the maximum effective use of wearing parts. *The result* —sharply reduced per ton maintenance charges.

The outstanding performance of the KENNEDY Cubers is due to rotor design. The rotor itself is welded, laminated, heavy steel plate. Three cast manganese steel hammers are rigidly attached to the rotor by an exclusive method that permits quick, easy adjustment for wear. The heat treated, alloy steel shaft is pressed and locked into the rotor core. Heavy duty, self-aligning, spherical roller bearings are rigidly attached to the heavy base frame in box section to stand up under the severe punishment of the breaking action. Manganese steel end discs, flush with the main housing liners prevent attrition of material between hammer ends and sides of the Cuber and prevent rounding of the hammer ends, confining wear to the manganese hammers.

This superior rotor is found only in the KENNEDY Cubers.



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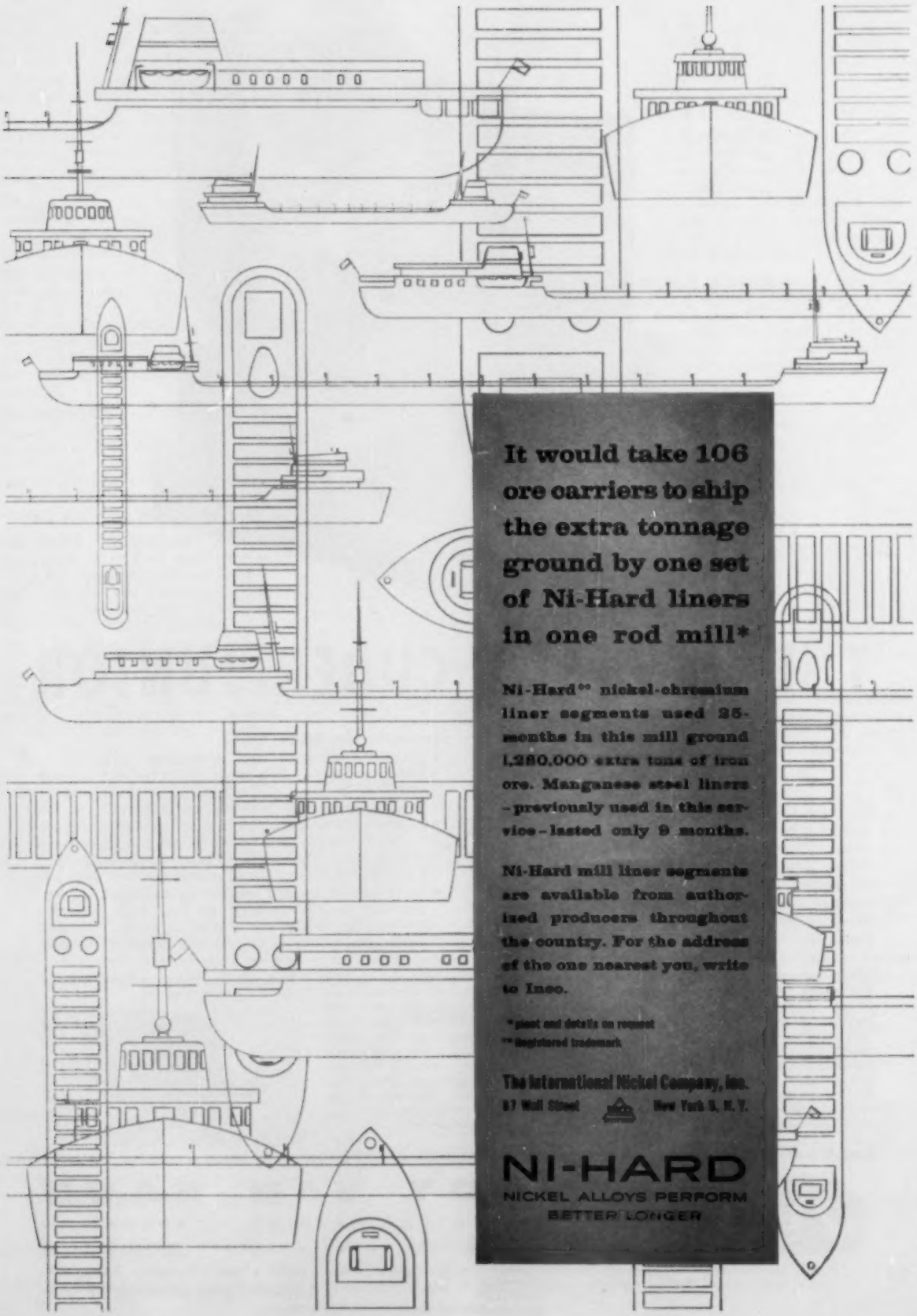

It would take 106 ore carriers to ship the extra tonnage ground by one set of Ni-Hard liners in one rod mill*

Ni-Hard nickel-chromium liner segments used 25 months in this mill ground 1,280,000 extra tons of iron ore. Manganese steel liners – previously used in this service – lasted only 9 months.**

Ni-Hard mill liner segments are available from authorized producers throughout the country. For the address of the one nearest you, write to Inco.

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NI-HARD
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Iron Ore Developments

Russian scientists exploring Antarctica have reported finding rich veins of high grade iron ore in an area claimed by Australia. The surveying group—part of an international effort to study the area—also reported finding evidence of a huge basin of ore underlying the continent's ice. . . . Humble Oil & Refining Co., prospecting in Alaska, reports discovery of iron ore following inspection of a geophysical anomaly in the Dillingham area . . . . Canadian iron ore shipments for the first eight months of this year were down from the 1957 level by more than 5 million tons.

New Asbestos Project

A group of companies, including the Johns-Manville Corp. affiliate in Canada, have joined Advocate Mines Ltd. in a plan to develop a chrysotile orebody in the Baie Verte region of Newfoundland. A 3000-tpd mill will be constructed, is expected to be producing in three years.

Establish Office of Minerals Exploration

Federal financial assistance in exploration for mineral reserves will be administered by the new Office of Minerals Exploration, which succeeds the Defense Minerals Exploration Administration. The new agency's program will differ from the DMEA program in three respects: 1) applicants must provide evidence that funds cannot be obtained from commercial sources on reasonable terms; 2) interest will be charged from the dates Federal funds are disbursed to operators; and 3) Government participation in any one contract may not exceed $250,000.

Cerro May Buy Consolidated Coppermines

Officers of Cerro de Pasco Corp. and Consolidated Coppermines Corp. have joined in talks to consider acquisition of Consolidated by Cerro. Consolidated has majority holdings in two large metal fabricating firms—Titan Metal Mfg. Co. and Rockbestos Products Corp.

Bunker Hill to Build $10-Million Fertilizer Plant

The sulfuric acid formed as a byproduct of Bunker Hill Co.'s lead and zinc reduction plants in Kellogg, Idaho, will be used by a $10-million fertilizer plant which the company intends to construct in the northwest. At present the Kellogg reduction plants produce 100,000 tons of acid annually and this output can be substantially increased through building more facilities for collecting and converting waste gases. The fertilizer plant is scheduled to have initial yearly capacity of 200,000 tons of fertilizer products and should be in production by July 1960. A site will be selected following market and technical surveys. J. D. Bradley, president, stated the plan was an important and logical part of the company's diversification program.

MINING engineering REPORTER

Foote Mineral to Ease Lithium Output

A slash in present AEC ordering of lithium hydroxide and the relatively small, though growing, industrial market will force Foote Mineral Co. to reduce rate of production of the chemical in the summer of 1959. The company, however, reports a recent general sales upturn and expects to resume production of electrolytic manganese at its idle Proctor plant.

Nuclear Prospector

England's National Coal Board has developed a nuclear gage for measuring densities of earth strata in coal prospecting. Unit includes a cobalt 60 source and low-voltage halogen-quenched counter. Borehole head is lowered by cable.

Nickel's Biggest Market

In International Nickel's latest interim report, J. F. Thompson, chairman, comments that stainless steels represent the largest single market for nickel. "While steel production as a whole has doubled in 30 years," he noted, "the output of stainless steels in the same period has doubled every 10 years."

Molybdenum's Price Up, Titanium's Down

Climax Molybdenum Co., div. of American Metal Climax Inc., raised prices for most molybdenum products by about 5 pct, effective November 1 . . . . Mallory-Sharon Metals Corp. reports price of titanium sponge in lots over 500 lb has been cut about 15 pct to $1.62 per lb.

Litigation on Shaft Sinking Method

In an action brought at Albuquerque, N. M., by C. Kremer Bain, mining engineer, against McKenzie & Whittle Contractors last June, a U. S. district court judge held that McKenzie & Whittle was using Bain's patented method for shaft sinking in an operation near Carlsbad. The court held that royalties should be paid for use of the method and that incidental changes in the shaft sinking did not free the user from an obligation to pay royalties.

Two Uranium Operations Reject Unions

Employes of Homestake-New Mexico Partners and Homestake-Sapin Partners voted against union representation in National Labor Relations Board elections held at the companies' uranium mines and mines near Grants, N. M., on October 15 and 16, 1958. Three unions were seeking to represent employes. In the Homestake-New Mexico Partners election the vote was no union 43; District 50, United Mine Workers 22; Uranium Metal Trades Council of Grants and Vicinity (AFL-CIO) 10; United Steelworkers (AFL-CIO) 3; challenged ballots 7. The vote in the Homestake-Sapin Partners election was no union 102; United Steelworkers 51; District 50, UMW 23; UMTC of Grants and Vicinity 12; challenged ballots 2; void ballots 1. Challenged ballots were not investigated by the NLRB because outcome of the elections would not have been affected.

Behind the Cover

The figures on MINING ENGINEER's Christmas cover come from one of the most beautiful books we have ever seen—*Mining in the Arts.*

Der Bergbau in der Kunst, by Heinrich Winkelmann in collaboration with Siegfried Lauffer, Christian Beutler, Walter Holzhausen, Erich Köllman, Hanns-Uhlrich Haedeke, and Eduard Trier. Essen 1958. Verlag Glückauf GmbH. 480 pp. (24 x 28 cm) with 62 colored plates and 330 black and white illustrations. Price: 98 DM. (Text in German.)

The actual figurines are described in the book as follows: "As compared to the already very graceful rococo statuettes, the quintet of the playing miners (picture 65 on page 112) appear even more languishing in sensibility. The five musicians are veritable rarities of carvings, treasures for exquisite taste. Five miners, all in black costumes, make music, oblivious to the world, enchanted by the sound of their instruments. The pale faces and the delicate hands made of ivory contrast expressively with the black of the wood. The woodcarver Simon Troger (1693-1798) has used the combination of ivory and wood most of all. This enabled him to compose larger pieces, since ivory is smaller in size by nature. His imitators used the same technique but they used wood for the larger parts of their masterpieces and the ivory only for the flesh parts. Notwithstanding, the name "Troger figurines" has been adopted for this kind of woodcarving even when they were obviously not by Troger, as probably is the case of this group of miners.

"With the lightness of the rococo period the serious themes of mining art in the 18th century fades away in the plastic art. And yet, these charming figurines which are so unassuming in their dimensions are the forerunners of the much bigger sized statues of miners created with inexorable seriousness and social responsibility by Meunier, a century and a half later."

Mining in the Arts attemps, for the first time, to present a complete survey of mining as represented in the fine arts from antiquity to the present time (not only from Europe, but from all over the world). Inasmuch as mining is one of the oldest of human activities, it would be no exaggeration to describe this iconographic work as a kind of universal history of art represented by examples from mining themes. The guiding motive was to present works of art with a mining background as the art of their time in the general context of the history of civilization, and to disclose the live interplay between mining and art through pictorial examples. The pictures reproduced in the book have been selected from nearly a thousand illustrations which have been collected through decades by the founder and director of the "Mining Museum" in Bochum, Heinrich Winkelmann, doctor of engineering. The collaborating art historians had therefore the priceless advantage of being able to make their selection from an almost inexhaustible

treasure of pictures from all the arts throughout the ages. The author and his collaborators, who are among the best known experts in their individual fields, have limited their historical comments to the essentials in order to let the art speak for itself through the richness of the pictures. The presentation extends from the bronze age to the present time, and includes examples from both the old and the new world.

Dr. Winkelmann contributes an introduction on the cultural achievements of mining. Professor Dr. Siegfried Lauffer of the University of Munich writes on mining in the art of the ancient world. Dr. Christian Beutler evaluates sculpture (Bildwerke) from the gothic to the rococo. The flowering of the mining theme in art from the 16th to the 18th centuries is expertly interpreted by the director of the "Municipal Art Collections" in Bonn, Dr. Walter Holzhausen (former curator of the "Grüne Gewölbe" in Dresden). The special fields of mining art are also considered. Thus there are contributions by experts such as the director of the Museum of Arts and Crafts in Cologne, Dr. Erich Köllmann, on porcelain, and Dr. Hans-Uhlrich Hadeke on coins, medals, and pewter. Finally, the well known art historian, Dr. Eduard Trier, author of several books on modern art, covers mining pictured in the industrial age. Professor Joseph Fassbender of Cologne was responsible for the reproductions.

The appearance and make-up of the book, which has been made possible through the generous support of the German coal mining industry, make it a fine work of art itself. With its 62 colored reproductions in large format and 330 exquisite black and white illustrations, the book is the most comprehensive international collection and interpretation of mining motives in artistic representation ever attempted. A number of hitherto unknown or little-known works of art are shown here for the first time, and in color. This book will be equally valuable as a history of mining and as a general history of art and civilization. The beauty of its appearance and content make this book a priceless piece of literature for everyone, layman as well as expert.

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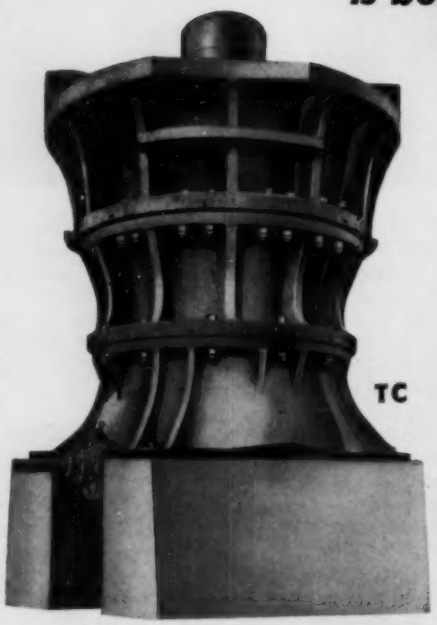

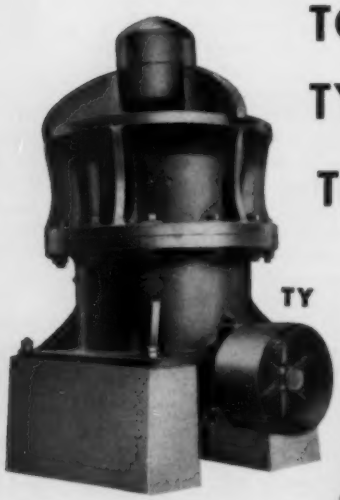

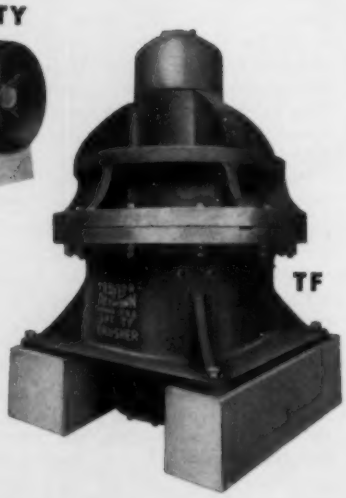

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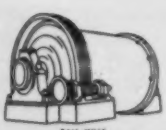
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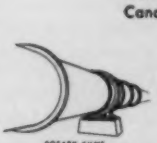
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Transactions of The Metallurgical Society—bimonthly

YES, MINERS, WE DO BELIEVE IN . . .

• FLASH—Jack Fox wants SME members to take particular note of the Monday morning (Feb. 19, 2000) Lunar Minerals Division session to be held in the Grand Ballroom of the Hotel Statler, New York. If enough SME members are interested, the Program Committee will reschedule this session as an all-Society meeting. Co-chairmen for the LMD session are Owney Geoghan, president of Lunar Worthree Corp., and Max Minimum, superintendent of Winken, Blinken, & Nod Inc. Three papers have been scheduled so far, with a fourth to be announced.

W. M. Kaeper, geologist, and F. X. O'Grogan, mine superintendent, both of Crater Mining Co., will discuss *Tungsten Deposits of the Crater District.*

Since things will be roaring at Crater, Lunar Territory, at the time of the Annual Meeting, Mr. O'Grogan won't be able to attend. However, Mr. Kaeper has promised to orbit in to present the paper and answer questions.

A. Gasper, Mine superintendent, Greencheese Mining Corp., plans to discuss some phases of *Mining Problems at No Air.* He hints that new procedures for handling nuclear muckers have been evolved at Greencheese.

What about tonnage? *Safety Practice under Low Gravity Conditions* will be thoroughly aired by J. Lightfoot, safety engineer for Noweight Lead Co. He hails from Leadzinc Junction, Lunar Territory.

At the moment, LMD is hoping to have a surprise speaker for the fourth spot on the session. Rumors reaching SME Headquarters suggest a paper on misty blasting powder for convex craters. Further announcements will follow in the January 2000 (MINING ENGINEERING's 50th anniversary number, you know) issue.

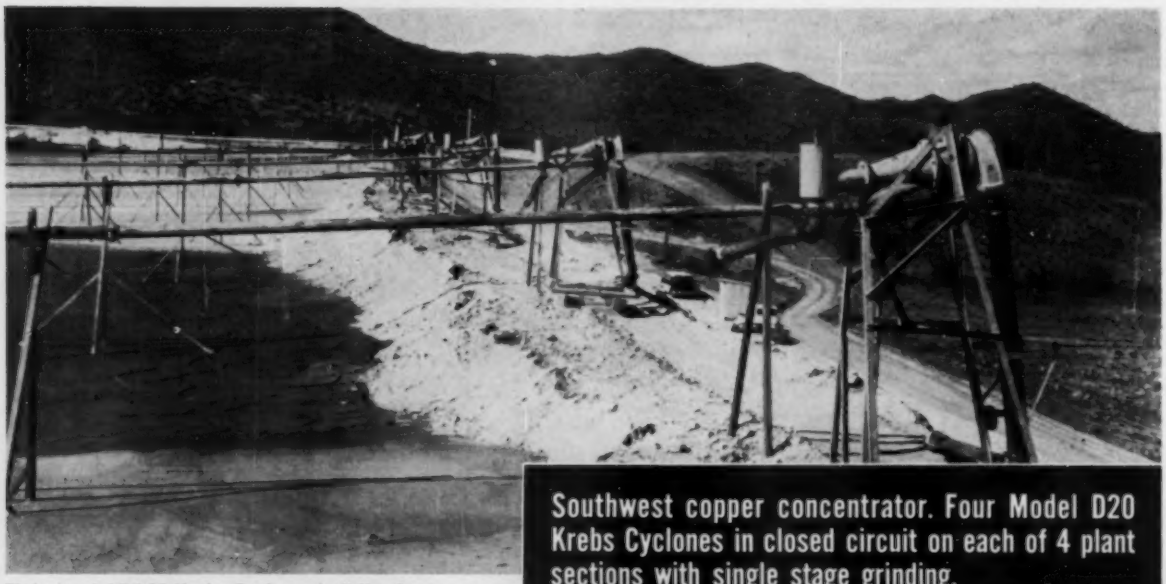
• MINING ENGINEERING believes that late presents are always a surprise and pleasure. ME's 10th Anniversary issue will be delivered in January when we will ask you to participate in our birthday celebration.

WISHING ALL . . .

A very Merry Christmas and a Happy New Year
from the Staff of MINING ENGINEERING

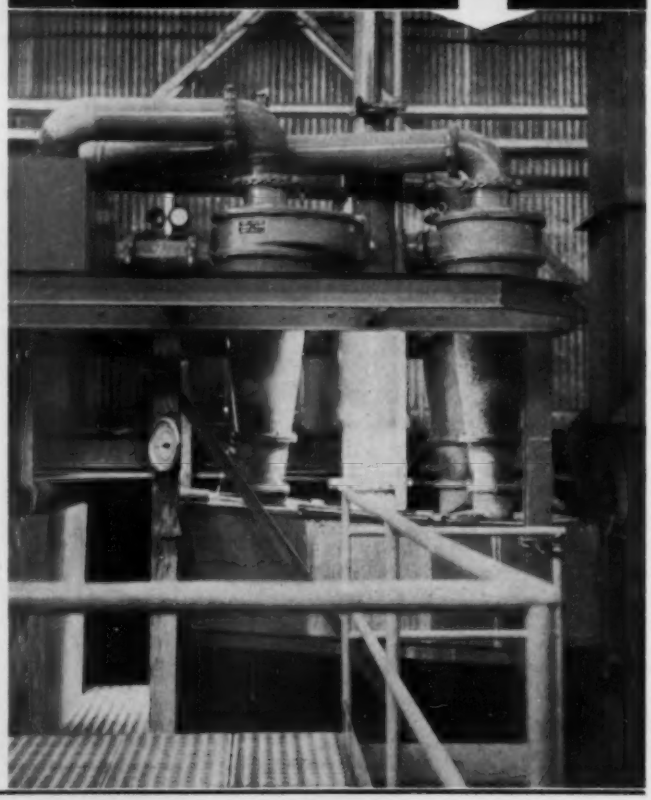
—R. A. Beals

Another copper concentrator changes to KREBS CYCLONES



Eight Model D10B Krebs Cyclones building berm for the tailings dam.

Southwest copper concentrator. Four Model D20 Krebs Cyclones in closed circuit on each of 4 plant sections with single stage grinding.



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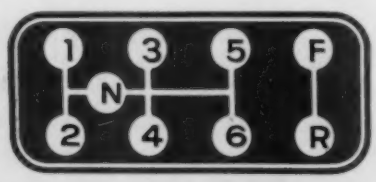

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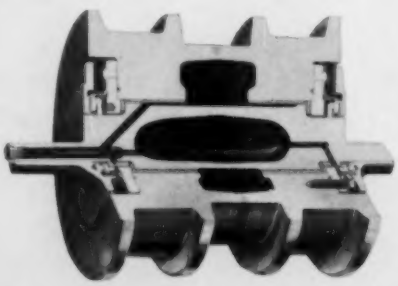

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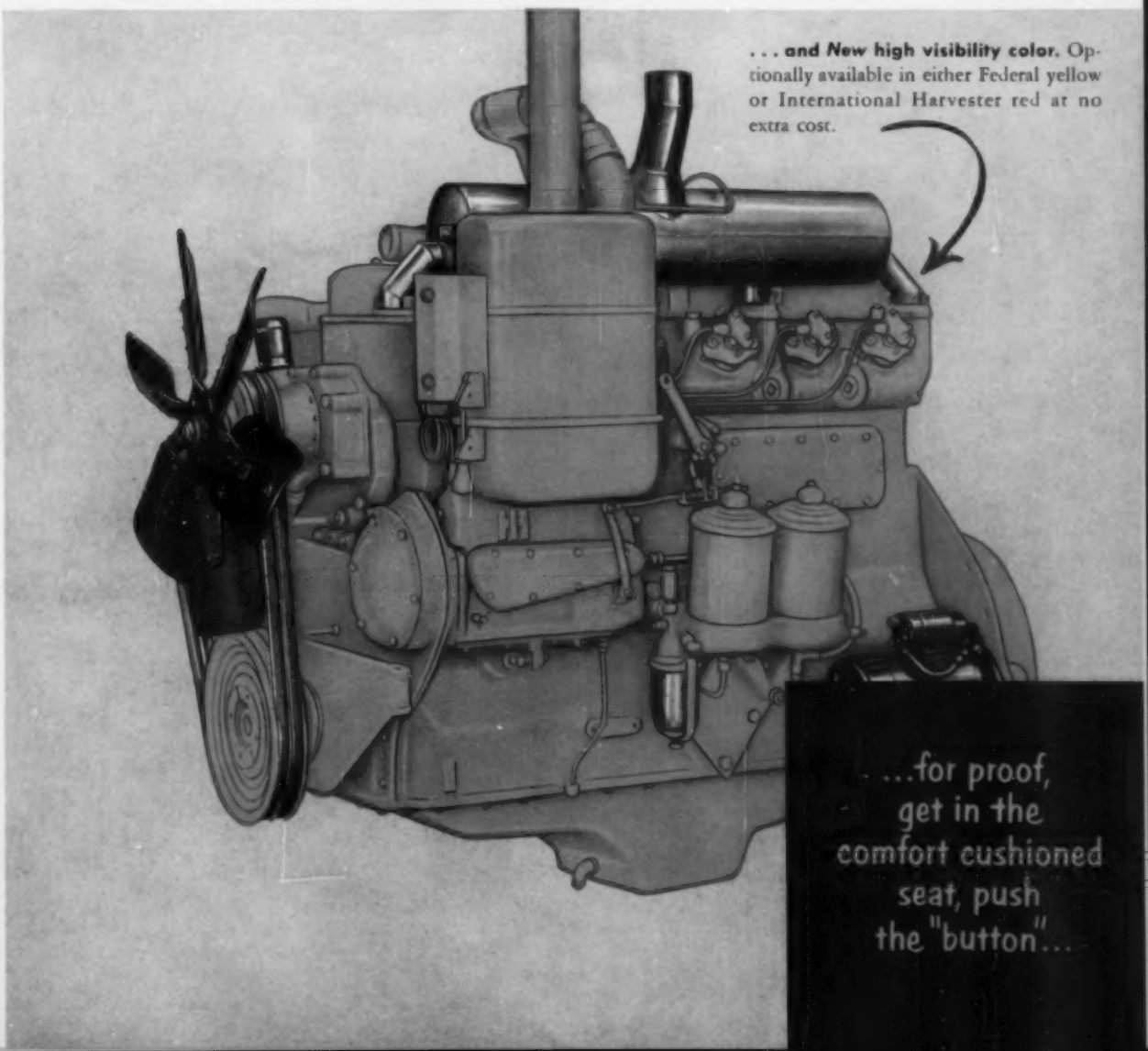

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SOCIETY OF MINING ENGINEERS OF AIME

AIME Annual Meeting, Feb. 15 to 19, 1959. SME Headquarters, Sheraton-Palace Hotel, San Francisco.

The Abstracts and Program are arranged alphabetically by Divisions with AIME Councils listed last. Deadline for receipt of abstracts at SME headquarters was October 20. Tear this section out of the magazine and bring it to the Annual Meeting with you, since no other abstract booklet will be distributed. Papers for which preprints are available are listed by number. These may be obtained **only** by mailing in SME coupon properly filled out. Coupon books containing five (5) coupons are sent to SME members with their dues bills. Other books can be purchased from SME Headquarters (29 W. 39th St., New York 18, N. Y.) for $5 (members) or $10 (nonmembers). Preprints **will not be** mailed out unless ordered by coupons.

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ABSTRACTS

COAL DIVISION

Session I

Hydraulic Mining of Gilsonite and its Application to Coal Mining by *John H. Baker*—Gilsonite, a solid hydrocarbon, is cut from a vertical vein by high pressure water jets mounted on a track-type vehicle at rates of 50 to 60 tph. The water used in the cutting process plus additional fluming water is used to transport the ore 2½ miles to a sump from which it is pumped to the surface by a series of horizontal pumps. After further preparation and adjustments of concentration, it is pumped 72 miles over a mountain range to a gilsonite refinery.

The author discusses the Russian method of jetting coal and the difference in the two systems as well as the possible application of jet mining for the coal industry. **59F3.**

Faults in Pitching Coal Seams—Their Effect on Mining, And Their Solution by *Albert M. Keenan and Robert H. Carpenter*—Geologic faults in western coal seams present many problems in mining which are not experienced in other coal producing regions in the U. S., and a knowledge of their occurrence often precludes the development of successful operations.

The Thompson Creek Coal and Coke Corp. in their operations in Pitkin County, Colo., has experienced the problem of complex faulting in seams of coal having a pitch of 30°. The effects of faulting have further challenged their efforts to carry on multi-seam mining in their high grade coking coal deposits.

Faults in pitching coal seams are frustrating in their effect on: 1) roof control; 2) quality control of mined product; 3) underground haulage of coal, both "secondary" and "main"; 4) handling of supplies and equipment underground; and 5) increased costs of mine development. These problems justify geologic exploration prior to and during development of the coal mining operations.

Two major types of faults which occur in the mines are the ones perpendicular to the trend of the coal seams which offset the seams laterally, and those which are along the trend and which drop the coal down from an up-pitch projection. Geologic engineering has been the key to the successful solution of faults in the pitching coal seams of the Thompson Creak Coal and Coke Corp.

Reducing the Bounce Hazard at Sunnyside by *Lynn P. Huntsman*—The paper deals with the problems of bumps which occur in Kaiser's Sunnyside mines and the steps taken to eliminate or reduce their danger. Receiving special emphasis will be types of roof control, such as wooden cribs, and the extensive use of steel yieldable arches along with the work being done in backfilling some of Sunnyside's old aircourses and haulageways.

Session II

Cleaning Plant Design for Minimum Operating Labor by *John D. Price and William M. Bertholf*—This paper may be described in one word, *automation*. How closely it may be approached will depend on the amount of money available. But even if it cannot be fully secured, any approach to it will result in savings in operating costs. This paper presents some of the conditions which must be considered, and mentions examples of automated plants. **59F5.**

Session III

Characteristics of Coal Preparation Plant Slimes by *H. B. Charmbury and D. R. Mitchell*—Waste slurries from eight bituminous coal preparation plants in Pennsylvania have been investigated to determine the amount of recoverable coal being lost in plant slimes. Losses ranged from 56 to 725 tpd with an average of 230 tpd. All of the solids in some of the slurries were sufficiently low in ash and sulfur that they represented salable coal provided they could be recovered and prepared in a form to be mixed with other coal sizes from the plant. Other of the slurries contained as little as 9 to 10 pct recoverable coal.

Based upon the average figure, over 4 million tons of recoverable coal are being lost as waste slurry material at the 96 coal preparation plants in Pennsylvania. Assuming a value of $5 per ton, this is equivalent to a $20 million loss per year. In some cases, known methods of coal-water separations may be used to recover this loss but more research is necessary to devise new, more efficient, and economical methods of recovering high grade salable coal from the run-of-mine product.

A Laboratory Investigation of Flocculation as a means of Improving Filtration of Coal Slurry by *M. R. Geer, P. S. Jacobson, and H. F. Yancey*—Three of the newer flocculants were compared with starch and lime in an investigation of flocculation as a means of improving the filtration of three natural and three synthetic coal slurries, using a standard test leaf for filtration. One of the natural slurries was comparatively clean coal, one contained a high proportion of clay slimes, and the other was a cyclone underflow from which most of the extreme fines had been eliminated. The synthetic slurries were mixtures of clean coal with three different types of clay.

The filter-cake rates and filtrate quality obtained with all of the slurries were improved by flocculation, the greatest improvement being with the slurries containing the most clay. Each slurry exhibited individual flocculation and filtration properties, and no one flocculant was superior for all slurries.

In general lime was the poorest of the flocculants tested. Some of the newer flocculants are so effective that only a few thousandths of a pound per ton was required to improve filtration greatly. However, with the slurries examined, the performance of these flocculants did not exceed that obtained with greater amounts of starch. **59F4.**

Session IV

An Investigation of Materials Used for Stoppings in Coal Mine Ventilation Systems by *Charles T. Holland and W. J. Skewes*—This paper presents methods used and results obtained by research on the properties of stopping materials used in the ventilation systems of coal mines. The properties investigated are strength, yield under load, porosity, and permeability of stopping material. Also, stoppings were constructed and tested for leakage as well as the application of plaster and paint to the high pressure side of the stopping to reduce leakage. Some data are presented on leakage through brattice cloth and the permeability of coal.

Safety With Continuous Miners in Steeply Pitching Coal Beds by *Louis H. McGuire*—The paper describes methods and safe practices of mechanized mining in steeply pitching bituminous coal beds of the state of Washington, with particular reference to the Roslyn-Cle Elum coal field and the use of continuous miners.

Continuous miners are used in driving entries where the coal bed dips up to 30°. At one mine where the coal bed ranges from 40 to 46 in. in thickness and dips 8° to 9°, continuous miners are employed in driving entries, rooms, and recovering the pillars. The continuous miner produces 130 to 135 tpd on the lighter dip as compared with 60 to 70 tpd under more difficult and slower operating conditions on a relatively steep dip.

The paper also describes the development of mechanical mining, mining methods, ventilation, conveyors, crosscut-boring machines, multiple shot blasting with millisecond delay detonators, and the use of the fog gun to allay dust, dust control, and safety.

Session VI

Removal of Sulfur Dioxide from Flue Gases At Elevated Temperatures by *Joseph H. Field and Daniel Bienstock*—The sulfur dioxide emitted in low concentrations in flue gases from the combustion of sulfur-containing coals and fuel oils is a significant factor in contamination of the atmosphere with sulfur dioxide. A review of methods for treating gases containing high concentrations of sulfur dioxide shows that they are generally not satisfactory for purification of flue gases. Processes developed specifically for treating flue gases using liquid absorbents are costly and may cause localized pollution because the cooled flue gases can settle in the vicinity of the stack.

Bench-scale research is being conducted to investigate the use of dry absorbents for sulfur dioxide removal at temperature levels of about 250° to 300°F and 600° to 650°F Alkalized alumina has been found effective for treating simulated flue gas and is regenerable by hydrogen, carbon monoxide, or producer gas. Other metallic oxides also have been tested as absorbents. Chemically impregnated activated carbons removed sulfur dioxide from the gas at a temperature of 265°F. Vanadium-pentoxide is effective as a catalyst for the oxidation of sulfur dioxide in the simulated flue gas at temperatures lower than have been used commercially for gases with higher concentrations of sulfur dioxide. Conversions of sulfur dioxide to trioxide were studied as a function of temperature over a range of about 570° to 750°F. **59F24.**

Coal Characteristics and Their Relationship to Combustion Techniques by *T. S. Spicer*—This paper reviews the typical characteristics of U. S. coals as defined by standard tests and shows their relationship to the principal types of combustion equipment. As a result of numerous requests which the author received for such a paper from nontechnical people, coal salesmen, purchasing agents, and coal customers, an attempt is made to summarize the subject for these readers. Essentially it covers the six major types of coal firing—single retort, multiple retort, traveling grate, spreader stokers, pulverized firing, and cyclone furnaces, and the types of coals normally used with these combustion machines.

Integration of Coal Characteristics with the Design of Large Pulverized Coal Steam Generating Units by *Douglas G. Hubert*—The electric utility industry in the U. S. has more than doubled its consumption of coal in the last ten years, and now uses one third of all coal produced. Two thirds of utility steam-electric power is generated by coal. The properties of coal which influence the design of pulverized coal boilers include proximate analysis, ash composition, fusion temperature, sizing, grindability, heating value. Of these, moisture, ash, and sulfur are far more significant than heating value. The boiler components which are influenced by these properties include fuel preparation and burning equipment, furnace, superheater, reheater, economizer, soot blowers, air heater, dust collectors, and fans. Utility systems are building larger plants and units. A new 500-megawatt steam generating unit will consume over 200 tph of coal. High availability is necessary to justify such size. To assure continuous supply of fuel, a large plant must buy from many and varied sources, often from new mines of low grade coal. More coal producers are giving serious attention to cleaning processes and this trend must continue. With rising costs, increases in unit size, and greater need for high availability, designers and operators will be placing greater evaluation on quality rather than on mere Btu content. It is thus incumbent on the coal producer to make available coals which have been better prepared and which are of more uniform quality over the life of the steam generating unit. **59F30.**

Session VII

Coke Combustibility: A Neglected Characteristic by *John D. Price*—Many attempts to correlate the laboratory results on physical properties of coke with blast furnace operation have failed. One reason for this may be that some property of coke has been overlooked in making such tests. This neglected characteristic could well be that of combustibility and this paper treats some of the theoretical aspects as well as means of measuring this. **59F6.**

INDUSTRIAL MINERALS DIVISION

Chemical Raw Materials

The Grand Isle Mine—Freeport Sulphur Co.'s Offshore Venture by *Z. Wilson Bartlett, C. O. Lee, and R. H. Feierabend*—Facilities and various engineering aspects of Freeport's plan for developing its Grand Isle Mine are described. The mine is located seven miles off the coast of Louisiana in the Gulf of Mexico where the water depth is 45 ft.

Humble Oil & Refining Co. discovered the sulfur deposit in 1949 while drilling for oil. Their further exploration in 1954 proved a deposit of major significance. In 1957 following approval by the Dept. of the Interior, Humble assigned its sulfur rights to Freeport Sulfur Co.

The Grand Isle Mine will have the third largest Frasch plant in the world, designed to heat 5,000,000 gal of seawater daily to 325°F for production use. Other facilities are being sized proportionately. Off-shore living quarters are provided for 120 men. Personnel will be transported offshore via helicopters.

All facilities will be set on steel, pile-supported platforms 75 ft above the water. Structures are designed to withstand the worst hurricane winds and waves which have been predicted for the site as well as some 15 ft of surface subsidence resulting from sulfur withdrawal.

Engineering studies are in progress to determine the best method for transporting sulfur to shore—whether by buried, heated pipeline or via heated barges; in either case the sulfur would remain molten.

Freeport began construction offshore in June 1958, and expects construction to be completed in late 1959; production should be started in 1960. Estimated cost of the facilities is $30,000,000.

Fluorspar for Water Treatment by *F. J. Maier*—The development of the apparatus and operating techniques used at the Bel Air, Md., water treatment plant are illustrated. Experiences over the past 2½ years with this equipment is described and the disadvantages discussed.

A new technique whereby these disadvantages are minimized or eliminated was developed for the water treatment plant at Rosiclare, Ill. The equipment used at this plant is described and operating results presented. This equipment is believed to provide a demonstration of the feasibility of this process for larger water works.

Recovery of Phosphates by In Situ Fluid Mining by *Sylvain J. Pirson*—A process has been developed by the author whereby phosphate deposits are leached in place by the injection of a weak solution of a recoverable acid much in the same manner as in the recovery of oil by water flooding. The phosphate mineralization is dissolved in place, selectively treated in a surface plant and a high grade dicalcium phosphate substantially free of fluorine (hence of feed grade quality) is recovered. Because of its powder form the plant product is also highly desirable as stock material for the manufacture of tripple super phosphate.

Details of fluid injection well patterns, areal sweep and solution efficiency, plant design, and economics are presented. **59H4.**

Colemanite as an Important Source of Borates by *William T. Griswold*—Borates are unique among industrial minerals in that free-world production is concentrated within a small area located on the southwestern desert of California. Present production and marketing are primarily associated with the sodium borates; however, new technological developments have increased the importance of boric acid and boric oxide. These compounds could possibly be produced competitively from upgraded colemanite (calcium borate) ores found in the same desert regions. Colemanite supplied the bulk of world requirements prior to the discovery of sodium borate ores at Kramer, Calif., and the development of methods for extracting borax from the brines of Searles Lake.

Geology of the southwestern borate deposits is strikingly similar. The relationship of certain types of basic volcanics, interbedded with tertiary lacustrine sediments, forms a pattern for the occurrence of large high-grade borate deposits. A summary of these factors, along with speculative theories as to the origin of mineralization, is of value in guiding any exploration program. Although the known colemanite deposits are not as large as the Kramer sodium borate orebody, they are numerous. Important new colemanite discoveries have been made recently, and the chance for additional discoveries is promising. **59H20.**

Potash in Saskatchewan by *Marion A. Goudie*—The Saskatchewan potash deposits occur in a large salt basin of middle devonian age. The potash, the final deposit in the salt basin, results from several interrupted cycles of evaporation and dessication. The deposits are extensive, and at first glance, relatively undisturbed. With more and more wells being drilled, it has now become evident that salt solution has played a large part in changing the original deposits, resulting in some cases in partial to complete removal of the potash and the underlying halite. The most dominant factor in the removal of salt by solution appears to have been tectonic movement and consequent faulting, probably of relatively minor dimensions but of major importance. Evidence which indicates the tilting of the evaporite basin to the north and northwest is shown by the changing pattern of the basin during succeeding eras of potash deposition. The potash minerals of most importance economically are sylvite and carnallite. Reserve calculations indicate that 6.4 billion tons of recoverable high grade potash in K_2O equivalent exist in the basin. **59H16.**

Rare and Radioactive Minerals

Joint Session with IndMD and SEG

Geology of the Montgary Pegmatite by *Richard W. Hutchinson*—The Montgary pegmatite is located at Bernic Lake in the southeastern Manitoba pegmatite district. It has a complex internal structure with several contracting mineral assemblages. The pegmatite contains a number of potentially valuable minerals including spodumene, amblygonite, lepidolite, zinwaldite, pollucite, and beryl. The occurrence of each of these is related to the internal structure and controlled by a specific mineral assemblage.

Parts of the pegmatite comprise a spodumene deposit of unusually high grade. The pollucite occurrence is of unique character and is one of the largest known deposits of this mineral.

The pegmatite is sill-like in attitude with a maximum dip of about 15°. Its contacts with the amphibolitic wall rocks are sharp and tourmalinized.

Mineral assemblages present include microcline-plagioclase-quartz-muscovite, cleavelandite-lithia micas-quartz, quartz-amblygonite, albite, lepidolite, pollucite, and quartz assemblages. The occurrence and relationships of these are described and possible relationships between attitude and internal structure are discussed.

Many features of the pegmatite suggest that the deposit formed by crystallization and differentiation of a pegmatitic fluid in a restricted system. The nature and occurrence of the lepidolite and pollucite assemblages are such, however, that it is difficult to visualize them resulting from such a system. These assemblages may be of later replacement origin. The source of the alkali-rich replacing solutions may be unmixing of the rarer alkalis (lithium, caesium, rubidium) from earlier formed silicates in a manner similar to the unmixing of sodium in perthites. Various aspects of this hypothesis are examined. **59H46.**

Environmental Factors Governing the Origin and Distribution of Heavy-Mineral Deposits on Padre Island, Texas, A Barrier Island by *Louis Moyd*—Padre Island is a narrow curved barrier island paralleling the Gulf coast from the mouth of the Rio Grande to Corpus Christi Bay, more than 100 miles to the northeast. Its axis trends N-S at the south end and E-W at the north end.

A recent investigation of heavy-mineral possibilities included an airborne radiometric survey and a systematic hand-auger and water-jet drilling program. Results indicate that heavy-mineral concentrations are limited to the extremities of the island. The heavy-mineral suite consists predominantly of iron-rich ilmenite, with various silicates and minor monazite. Sediments are derived from the Nueces River at the north end and the Rio Grande at the south end.

Strong onshore winds from the southeast predominate, and the resulting waves cause long-shore migration of the sands toward the middle of the island from both ends. Transport is accompanied by winnowing action, thus the proportion of heavy minerals decreases progressively toward the middle of the island. Sands do not accumulate in the middle zone in the usual shore-straightening pattern. Instead, because of the extreme aridity, wind removes the sand and deposits it on the Brooks-Kennedy sand plain which extends for more than 60 miles inland. The heavy-mineral concentrations are associated with present or fossil foredunes. Transgressive dunes are formed at the expense of the foredunes, and the process of heavy-mineral concentration by windaction can be readily observed. Stormwave concentrations are almost completely lacking, since the Gulf is shallow for a long distance off-shore, thereby reducing the force of the waves.

Thorite and Rare Earth Deposits in the Lemhi Pass Area, Lemhi County, Idaho, by *Alfred L. Anderson*—Thorite and rare earth deposits in the Lemhi Pass area of southeastern Lemhi County, Idaho, are contained along complex shear and fracture zones and

in reopened gold-quartz veins and copper lodes in quartzitic and phyllitic rocks of the pre-Cambrian belt series. Some of the shear and fracture zones are several tens of feet across and comprise broad zones or irregularly mineralized rock. These lodes contain a notable concentration of thorium and rare earth elements along with considerable amounts of barium, potassium, calcium, iron, aluminum, phosphorus, sulfur, and silicon. The principal minerals are thorite, locally allanite, monazite, xenotime(?), apatite, specular hematite, barite, potash feldspar, or occasionally calcite and quartz. Except for some of the specular hematite, barite, reddish feldspar, calcite, and quartz, the minerals are not distinguishable without the microscope. The thorite and locally allanite were deposited first, then the monazite and other phosphates, which were in turn followed successively by barite, potash feldspar, calcite, and quartz. In exceptional cases, deposition of thorite and specular hematite was repeated after the feldspar. Some of the deposits contain several percent thoria, but the average is generally under 1 pct. The rare earth content is comparable with that of the thoria.

The deposits appear to be of hydrothermal origin and are probably related genetically to late Cretaceous or early Tertiary igneous activity, manifested locally by a few dioritic and lamprophyric dikes.

Radiographic Distribution Analysis Applied to Uraniferous Pyrite, Galena, and Sphalerite by *H. D. Wright, J. J. Hutta, W. P. Shulhof, and C. M. Smith*—A sensitive new method for evaluating homogeneous distribution of trace "impurities" in minerals should have important application in geologic trace element studies. Interpretation of data on trace elements generally has been seriously handicapped by the lack of satisfactory means for establishing their role—whether in admixed minerals, crystal coatings, open space deposits, exsolution bodies, or crystalline solid solution. For many purposes a solid solution role is of exclusive interest. The present method supplements direct microscopic search for impurities with a statistical test of homogeneous distribution of tracks in autoradiographs.

The method has been applied in an evaluation of trace uranium content of certain base metal sulfides, coexisting with uraninite in vein deposits, as an index to the uranium concentration of the parent solution. It was necessary to establish that the uranium had not been simply included or subsequently introduced, and, for a satisfactory analysis of correlation with bulg ore uranium grade, to use only samples in which the uranium had been incorporated during crystallization. Analysis of microscopically picked, acid-cleaned pyrite, galena, and sphalerite showed a uranium concentration ranging from less than one to several thousand parts per million, in apparently homogeneous material. In 102 samples of pyrite from 42 deposits, homogeneous distribution was found only in 58 samples containing less than 70 ppm uranium. A similar copper limit for homogeneously distributed uranium has been found thus far in smaller numbers of galena and sphalerite samples.

The method is being applied in crystal synthesis studies using radioisotopes yielding charged particles. Under favorable conditions, certain stable elements in natural samples may be studied after radioactivation.

Economic Uranium Deposits in Granite Dykes at Bancroft, Ontario by *S. C. Robinson*—The deposits occur in an area extending 25 miles southwest from Bancroft in eastern Ontario. Three mines with plants capable of treating more than 1000 tpd are in operation and another is shipping ore. Grades are of the order of 0.1 pct U_3O_8 and from 0.025 to 0.2 pct ThO_2.

The region is underlain by pre-Cambrian granitized paragneiss and lime-rich metamorphic rocks which have been intruded by three major granite batholiths. The great majority of the uranium deposits including all the economic ores, are distributed in the rocks mantling the batholiths. A few, however, occur within the batholithic rocks.

The economic deposits occur in pegmatitic granite dykes but uranium is found also in zoned pegmatites, in a variety of metasomatic deposits, and in calcite-fluorite-apatite "veindykes." Principal uranium minerals are uraninite-thorianite and urano-thorite with minor betafite and allanite. Zircon is generally present and is locally abundant and its distribution is closely parallel to that of the uranium minerals. Although the various dykes of uranium deposits contain distinctly different aggregations of minerals, calcite, and fluorite are common to nearly all of them.

Water Problems

Water Laws as Related to Dredging in Idaho by *Robert P. Porter, Richard B. Porter, and Robert A. Lothrop*—Porter Brothers Corp. is successfully operating a unique dredge mining property in Idaho. One of the basic problems confronting this operation is the Idaho Dredging Mining Protective Act of 1954 which requires miners to reasonably clarify the water used in the mining process before such water is discharged into streams.

The system used to clarify the dredge water has three components: 1) a method of isolating the dredging area from excess surface water, 2) an efficient semi-portable clarifier, and 3) sufficient storage for clarifier sludge.

The system not only fulfills the basic requirements of the law, but also keeps the stream immediately below the dredging area crystal clear. **59H9.**

Land Subsidence in the San Joaquin Valley, Calif.—Methods of Investigation and Preliminary Findings by *J. F. Poland*—Land subsidence has occurred in three large areas of intensive ground-water withdrawal in the San Joaquin Valley, Calif.; also, at the north end of the valley in the Sacramento-San Joaquin Delta where the water table in peat deposits has been lowered by drainage.

Subsidence in the Los Banos-Kettleman City and Tulare-Wasco areas is being investigated intensively by an interagency committee of Federal and state agencies.

Methods of investigation include periodic releveling of a closely spaced net; establishment of depth bench marks in wells as much as 2000 ft deep to obtain a continuous record of compaction or expansion of deposits; measurement of water-level fluctuation and correlation with rate of compaction; laboratory tests of cores to determine physical, hydrologic, petrographic, and engineering properties of deposits; correlation of known change in load with results of laboratory tests, especially the consolidation tests; and application of water to test plots to observe compaction of deposits at shallow depth above the water table. The investigation has shown that the subsidence has two principal causes: 1) regional compaction of deposits below the water table, due to a major decline in artesian head accompanying heavy withdrawal of ground water from confined aquifers; the compaction has caused subsidence of as much as 20 ft; and 2) compaction of deposits above the water table locally, due to application of irrigation water, which has caused as much as 100 ft of subsidence.

Water Law and Its Significance to the Mining Industry by *Wells A. Hutchins*—Water law has been closely related to the mining industry in the West since the Gold Rush days, when the California miners developed a system for prior appropriative water rights that is now in effect in all western states. Also in some of these states is the riparian doctrine, which allows the owner of land contiguous to a stream to use the water for beneficial purposes on his land. In some areas the owner of land overlying a ground water supply has rights to use the water; elsewhere he must appropriate it. The use of water for mining purposes—exploration, drilling, running machinery, milling, domestic use in mining communities, etc.—is a reasonable beneficial use of water for which a water right may be acquired and exercised. This holds equally true in petroleum mining with respect to drilling, recovery, refining, and probably secondary recovery operations. Other features of water law that affect the mining industry relate to the disposal of excess water after its use in mining, milling, and refining operations, and to the disposal of waste materials into watercourses. To avoid suits for damages and injunctions, methods of disposal must be such as not to inflict substantial injury upon private property holders, and they must conform to public regulatory measures. **59H1.**

Relation of Land Subsidence to Groundwater Withdrawals in the Upper Gulf Coast Region, Texas by *A. G. Winslow and Leonard A. Wood*—Subsidence of the land surface has occurred in several areas of the upper Gulf Coast region of Texas, and in most of the areas the subsidence seems to be related to the removal of ground water. In the principal area, which is in the vicinity of Houston and Galveston, heavy withdrawal of ground water from a series of unconsolidated sands interbedded with clays has caused regional land-surface subsidence.

Most of the subsidence is attributed to compaction of clays and other fine-grained materials as the artesian pressure head is lowered in the water-producing sands. The rate of subsidence has been approximately 1 ft for each 100 ft of decline of artesian pressure head. Recent releveling has shown no appreciable change in the rate of subsidence.

Subsidence of more than 2 ft has taken place in downtown Houston, most of it since 1933. The greatest subsidence observed to date is about 3.5 ft in the Texas City area.

Most of the ground-water development and decline of artesian pressure head has taken place in the deeper sands; however, most of the compaction apparently has occurred in the clays interbedded with the shallow sands. The subsidence probably will continue indefinitely even if ground-water withdrawals are not increased, because the head in the shallow sands will continue to decline as it adjusts to the lower heads in the deeper sands. **59H2.**

Special Sands and Abrasives—Fillers, Fibers, and Pigments

Rapid Method for Determining Feldspar Content in Felspathic Sands by *Hugh H. Bein*—Some purchasers of silica sands have set up quite rigid specifications on Al_2O_3 content in their raw material.

To a plant producing silica from felspathic sands, control of the feldspar content in the quartz fraction is quite important.

The orthodox chemical determination of Al_2O_3 is lengthy and involved and is not rapid enough for flotation control purposes.

A method, here described, is fast and gives a close approximation of the feldspar content in a sample.

The technique consists of sample splitting, sizing, etching with HF, dyeing, and grain counting. Comparisons are shown between the described method and the standard chemical procedure. **59H8.**

Marketing Trends for Selected Mineral Fillers by *W. F. Dietrich*—Recent trends are reviewed in the supply and consumption of selected mineral fillers in the U. S. and in the 11 western states. Special consideration is given to asbestos, clays, diatomite, limestone, talc, soapstone, and pyrophyllite and their technologic and commercial utilization in the major consuming industries. Economic growth projections to 1975 are applied to tentative forecasts of the mineral filler markets in the Western States.

Diatomite—A Current Review by *Arthur B. Cummins*—Diatomite is an industrial mineral material of considerable interest to the state of California. Thus, for some 40 years this state has led the world in the production of diatomite products and should maintain this position for many years to come. In recent years, diatomite has ranked relatively high in the mineral commodity list of California. While there are numerous diatomite localities throughout the state, the large commercial activities at present are confined to northern Santa Barbara County, in the Lompoc area.

In 1958, the major commercial operations are in California, Oregon, Washington, and Nevada. Deposits not being operated at present are known in all of the other states west of the Rockies and in most of the states along the Atlantic Coast.

Commercial diatomite deposits occur in many parts of the world—Germany, France, Denmark, Algeria, Japan, Brazil, Ireland, the Soviet Union, and others. An analysis is made of the world resources and their present commercial significance.

Estimated world production of diatomite is approaching one million tons per year; of this the U. S. supplies somewhat more than one half in tonnage; considerably more in dollar value.

A brief discussion is given on presentday methods of exploration, mining, milling, and preparation of diatomite for the market. The properties required for the various commercial uses are considered.

The uses for diatomite products come within the following fields: filtration, filiers, insulations, absorbants, abrasives, process applications, sources of silica, structural materials, cementitious admixtures, conditioning agents, and miscellaneous. The relative importance of these uses has varied considerably during the past 50 years. Several important new fields have been developed within the last decade. Present and anticipated new uses are discussed, with some look into the future.

Man-Made Industrial Diamonds by *J. D. Kennedy*—Just as the alchemists of old spent their lives dreaming and working to convert lead into gold, so, too, has man wondered how diamonds might be made artificially. The various attempts to synthesize diamonds are traced and the geologic investigations into the formation of the stones are discussed. General Electric's successful project is described in detail. Insofar as present abrasive applications are concerned, the current technology and production seem to fulfill the demands for industrial diamonds. An increase in the number of uses and applications is predicted, since the synthetic stones will be available in unlimited supply.

Cement, Limes, and Gypsum—Mineral Aggregates—Dimension Stone and Slate

Franciscan Chert in California Concrete Aggregates by *Harold B. Goldman*—Concrete aggregate sources in the Coast Ranges have been viewed with suspicion because they contain large proportions of Jurassic-Cretaceous Franciscan chert. The Franciscan chert has been categorized with cherts of the Miocene Monterey group as being potentially chemically reactive with alkalies commonly found in portland cement. Comparisons of the geologic occurrence, petrography, chemistry, and origin of these two rock types reveal many differences, the most important being that the Monterey chert contains significant amounts of highly reactive opaline material; while the Franciscan chert contains less reactive chalcedonic silica.

Laboratory tests demonstrate that the Franciscan chert is moderately reactive. Mortar bar tests made with crushed Franciscan chert and high alkali cement showed harmful expansions due to reactivity, when the proportion of chert exceeded 10 pct in each sand size. Data on the distribution of Franciscan chert in deposits of the major Coast Range streams are presented to show that the proportion of chert in the gravels rarely exceed 15 pct and in the sand rarely exceeds 10 pct. Field examination of mass concrete structures built with sand and gravel containing Franciscan chert reveal no signs of alkali-aggregate reaction after 20 to 50 years.

Commercial aggregates or potential materials in streams draining terrains underlain by Franciscan rocks should not on the whole be considered suspect of alkali-aggregate reaction because of their chalcedonic chert conduct. Except in a few cases, these deposits do not contain the chert in large enough proportions to cause harmful expansions.

Aggregate in California by *T. E. Gay, Jr.*—California has been the nation's leading producer of sand, gravel, and crushed stone aggregate since 1939; the state's 1956 yield of about 85 million tons was about twice that of the next most productive state. Aggregate production is distributed throughout California, but concentrated near metropolitan areas where aggregate is required for housing, industrial buildings, and highways construction. The low unit price of aggregate requires proximity of quarries to sites of use to minimize transportation costs.

Sand and gravel aggregate is slightly preferable for portland cement concrete, and crushed stone aggregate for asphaltic concrete, but depending on economic conditions, they may be used interchangeably. Quality and size grading characteristics are comparable for both types of concrete. Under normal conditions, sand and gravel deposits are cheaper to quarry and process for aggregate than are ledge rock deposits, from which crushed stone aggregate is made; different transportation costs may overcome this difference.

Three main types of sand and gravel deposits occur in California: 1) river and dry wash deposits, 2) beach and dune deposits, and 3) bedded Tertiary sandstone deposits. River and dry wash deposits account for more than 90 pct of California's aggregate output.

California has several major aggregate producing districts: 1) Los Angeles area, including adjacent districts in Orange and San Bernardino Counties, where extensive dry wash deposits occur; 2) San Francisco Bay area, where crushed stone aggregate from Contra Costa, Marin, and San Mateo Counties supplement river deposits in Alameda, Santa Clara, and Sonoma Counties; 3) San Diego; and 4) Sacramento areas both supplied by river deposits.

Modern Classification Methods Applied to Fine Aggregates by *C. E. Golson*—Modern technology of both portland cement concrete and asphaltic concrete are requiring better aggregates both as to quality and as to size gradations. Although based on same fundamental laws as that of classification in the ore dressing industry, the classification of aggregates has a totally different purpose. The items of equipment developed to meet these conditions are developed from similar machines used in the ore dressing industry but with modifications required to meet problems peculiar to this industry.

Types of equipment covered are the classifier, the scalping tank, the hydraulic classifier, and the cyclone. Some of the specific problems encountered in this industry are analyzed and possible solutions suggested.

Flow of Limestone and Clay Slurries in Pipelines by *Ross W. Smith*—A modified Reynolds number for use with Bingham plastic-type non-Newtonian slurries flowing in pipelines has been developed. Limestone and clay slurries approach Bingham plastic behavior. The modified number when plotted against the friction factor from the Fanning equation gives a plot in the laminar flow region identical to the one obtained on the standard Reynolds number chart with Newtonian fluids. Since flow in pipelines handling thick limestone and clay slurries is usually in the laminar flow range, it is possible from the modified Reynolds number chart to predict friction losses due to flow of Bingham slurries in pipeline of any diameter if two materials constants are known. The materials constants are plastic viscosity and yield stress. These constants can be determined either by measuring pressure drop over a known length of pipeline at varying flow velocities or by applying suitable factors to Stormer viscometer data. **59B14.**

CO_2 Gas as Slurry Thinner by *Duncan Williams and Harold Potter*—One of the major factors of economy in wet process cement plants is the number of pounds of water evaporated for each barrel of clinker produced. Experimentation and actual plant operation has covered the use of many admixtures for the reduction of this water. All raw materials are not affected in the same way by each chemical.

This paper covers the benefits derived from the grinding of bentonitic and hydrophilic raw materials in at atmosphere of rotary kiln flue gases containing approximately 25 pct CO_2. **59B15.**

MINERALS BENEFICIATION DIVISION

Crushing and Grinding

The Gyratory Ball Mill, Its Design, Principle of Operation, and Performance by *Arthur W. Fahrenwald*—A progress report is given on gyratory ball mill research. Mills ranging in size from 6 to 30-in. have been studied. The mill is well advanced mechanically in these sizes. Bearings are of the ball or roller type. Power is transmitted to the mill by vertical motor and V-belts. There are no gears. The controlling basic factors involved in the design, operation, and performance of the mill are listed. Experimental data are presented showing the effect of these factors on power, ball potency, and grinding efficiency. Based on these data an empirical formula has been evolved which prescribes with uncanny accuracy the magnitude and relationship of these factors for maximum power draft, capacity, and efficiency for any size of mill. A novel and effective design for controlling the nature of the flow of the grind phase (dry solids or slurry) through the grinding media (balls), has been worked out. When it was discovered that the mill could be fed axially, and discharged outwardly over the rim of the shell, a number of problems were solved—and a number of desirable conditions achieved. It made possible a large variation in feed rate without congesting the system. The number of ball impacts, the time of residence of the grind phase in the grinding media, and the number of particles to be crushed at any instant all increase in the same direction. A report of a duration test with a small unit, by independent engineers and in an independent research laboratory grinding copper and zinc ores, gave the following: ball potency, 300 pct; efficiency, 125 pct; and ball and liner wear, 48 pct—as against 100 pct for a 10-ft commercial tumbling mill. The tentative conclusion is that crushing is largely by impact. **59B35.**

Pebble Milling Practice in the Reduction Works of the Gold Mines of Union Corp. Ltd. by *O. A. E. Jackson*—The paper describes details of pebble milling practice in the reduction works of the Gold Mines of Union Corp. Ltd. in South Africa. **59B17.**

Solids-Fluid Separation (Symposium)

Countercurrent Decantation: When and Why by *Elliott J. Roberts*—The basic principle involved in countercurrent decantation (CCD) with thickeners is also used in connection with other types of equipment. In general it can be called the "solids concentration-solution dilution" principle. The other basic principle used in washing solubles from solids is the "solids concentration-solution displacement" principle, as exemplified by filtration with displacement washes, generally in countercurrent relationship. Many washing circuits use both principles.

Fairly well known laws govern the operation of both principles. With a thorough understanding of these relationships and full information on a specific problem, the correct equipment and circuit choice can be made. This full information includes equipment performance and size data on thickening, filtration, centrifuging, screening, and classification, as well as a knowledge of how much wash water can be absorbed by the circuit at no cost, plus the unit cost of disposing of additional wash. The filtration data must include displacement efficiencies and if there is adsorption, the adsorption isotherm must be generally known.

In the last analysis the *why* is generally a matter of economics, so that *when* is when CCD by thickening shows the lowest overall costs. However, in making the analysis, it is necessary to have in mind at all times just how each step in any circuit affects the costs, both capital and operating, so that the optimum flowsheet may be chosen, and allowances made for a management preference for low capital costs even at a higher operating cost.

Thickening Leach Residues in the Sherritt Gordon Nickel Refinery by *D. J. I. Evans and S. C. Lindsay*—The problems encountered in the thickening of the ammonia leach residues during the first few months of operation of the refinery are described and the methods for solving the problems are enumerated. Although countercurrent decantation (CCD) was not incorporated into the refinery flow-sheet, the results of the thickening studies reported, and the experience gained, are pertinent to CCD particularly where CCD is to be applied to slow-setting slurries from a hydrometallurgical leaching operation.

After a brief description of the circuit for treating the Ni-Cu-Co-Fe sulfides, the factors affecting the thickness design are discussed and the characteristics of the slurries thickened are enumerated.

Correlations are given relating the problems experienced in thickening the slimey hydrated iron oxide leach residues during the start-up period with the refinery operation. Sliming of the thickeners was overcome by the use of powerful synthetic flocculants (which were becoming available in commercial quantities at that time), by modifying the agitation in the leaching vessels, and by decreasing the retention time during the leach by increasing the solids throughput. Improvements to the underflow pumping systems enabled the underflow pulp density to be satisfactorily controlled and eliminated the periodic torque overloading of the rake mechanisms. By improving the settling characteristics of the slurries, the solution surge storage capacities of the thickeners was greatly enhanced.

The present methods for routine operation of the thickeners are described and the procedures followed during shutdown and abnormal operating periods are detailed.

The paper is concluded with a discussion of the factors influencing the selection of a thickener-filter installation rather than a CCD liquid-solids separation circuit, at the time that the refinery was designed, and those factors are reviewed in the light of recent developments. **59B37.**

Separation and Washing of Alumina Process Residue by *Morton Handelman*—The extraction of alumina from its ore is the initial step in the production of metallic aluminum. This is most commonly done by the Bayer process in which a caustic solution is used to dissolve hydrated alumina from the insoluble materials with which it is associated in bauxite.

At the 2000-tpd Sherwin alumina plant of Reynolds Metals Co., the extraction residue from Caribbean ores is removed from the main process stream as the underflow of a continuous clarifier-thickener operation. This sludge, prior to its ultimate rejection from the process, is washed in an eight-step continuous countercurrent decantation system to recover physically entrained mother liquor.

Control of alumina production costs requires the optimum recovery of solubes from this residue which is generated at the same rate as the finished product. The equipment, operating techniques, controls, and process variables which affect the efficiency of this soda recovery from Bayer process red mud will be discussed. **59B10.**

Materials Handling

The Wobbler Feeder by *T. A. Oberhellmann*—The wobbler feeder is a comparatively new and revolutionary materials handling and separating device, originally adapted and intended for the separation of oversize particles from mine-run ore and the separation of oversize

materials from overburden, when the removal of oversize material is necessary, as in the case of conveyor stripping.

The paper will deal with the design of the feeder, wobbler bars, and various sizes. The original feeder, a 12½-in. pitch machine, was designed to remove particle sizes from 2½ to 7½ in. Feeders have been developed since which will remove ½-in. materials, oversize going to crushers, stock-piles, or elsewhere.

It is the only device which will actually feed, scalp, or remove specification particle sizes under adverse and high-moisture conditions, performing an operation which is impossible from any other screening or scalping device.

The paper deals with the applications that have been developed in various industries and is accompanied by a film showing three different wobbler feeder applications.

Flow of Bulk Solids—Progress Report by *Andrew Jenike, P. J. Elsey, and R. H. Woolley*—Bulk solids flow project is carried out under the sponsorship of MBD and under the financial support of Engineering Foundation, the University of Utah, and industry. The project is now in its third year. The first year was spent mainly on designing and equipping a Bulk Solids Flow Laboratory at the Utah Engineering Experiment Station, University of Utah, and on working out a detailed plan of research. During the second year, the plan was tested and found wanting; the authors found themselves unable to formulate general recommendations for the design for flow of bulk solids without a more comprehensive mathematical theory of flow. Turning to the field of rheology a study was carried out in conjunction with Professor R. T. Shield of Brown University. It was concluded that a theory of flow based on the theory of plasticity of Coulomb solids should be tested. This test is now in process.

Theoretical considerations have also caused modification of the method of measuring the flow-factor of bulk solids. During the past year the reliability of the tests have been improved to the point where comparison can be made of the flow characteristics of different materials.

The correlation between the flow-factor of the material and the behavior of that material in storage has so far been gained experimentally through industrial observations and laboratory tests. The mathematical theory is more advanced, results can be generalized. The paper describes the Bulk Solids Flow Laboratory, gives correlation data, belt feeder pressures, and a number of general design conclusions which will help to assure satisfactory material flow.

Belt Conveyor Power Studies by *A. W. Asman*—Design handbooks published by the conveyor machinery and belt manufacturers all show somewhat similar methods for determining power requirements for belt conveyors. Loads on idler bearings are multiplied by appropriate factors and the resultant tension is found for a unit of length. Differences in operating characteristics along the length of the conveyor are not considered.

In 1953, Hewitt-Robins established a research grant at Pennsylvania State University for the purpose of investigating fundamentals of belt conveyor operations. During the course of this contract, data were obtained on 14 belt conveyor installations which were augmented by laboratory experiments on individual components. The field conveyors were located in five states and carried coal, stone, and iron ore. Operating temperatures ranged from close to 100° to a low of 10°F.

At the conclusion of the 2-year Penn State study, all of the information was assembled and some applications were made. In order to expand the use of the developed principles, similar studies were continued by Hewitt-Robins engineers. These studies, now continuing, were made on high capacity, high speed belt conveyors.

Investigations to date establish several new but well founded principles of belt conveyor power requirements: 1) about 80 pct of the power is required to move the loaded carrying strand; 2) on the same conveyor, the power is inversely proportional to the carrying strand tension; 3) current manufacturers handbooks all are too conservative except for very short conveyors; and 4) air temperature is a major factor in designing belt conveyor power components.

Results of all investigations to date can be combined into an isobestic chart showing the effects of tension and other conditions. Factors from this chart allow the designer to make a more balanced and economical belt conveyor design.

Concentration

Scrubbing of Mesabi Range Intermediate Iron Ores by *William R. Van Slyke and R. C. Ferguson*—In an effort to improve the competitive position of Mesabi Range gravity concentrates, scrubbing of various size fractions of the crude oil is being practiced. Laboratory test work, correlated with plant results, is presented to show grade improvement of scrubbed material after heavy-media treatment, compared with unscrubbed material receiving the same subsequent treatment.

Two Years Milling at Bicroft Uranium by *D. F. Lillie, W. J. Dengler, and I. C. Edwards*—The first producing mine in the Bancroft area of southeastern Ontario has been processing pegmatitic ore containing uraninite and uranothorite since late 1956.

Features of the process are secondary grinding with pebbles, leaching with sulfuric acid, separation and washing of the residue by five-stage CCD, and clarification of the pregnant liquor on rotary precoat filters. The liquor is purified and up-graded in fixed bed ion exchange columns and the uranium is precipitated out by magnesia. Designed for a throughput of 1000 tons, the plant is currently processing 1400 tpd with a recovery of better than 92.0 pct.

Detailed operational data is presented concerning the effect of various factors upon extraction in the pachucas, and the control of impurities and resin poisoning agents. A description is given of the numerous physical and metallurgical changes which have been made to improve the plant operation. The problem of calcium sulfate deposition in neutralization tanks and tailings pipe line is also discussed.

High-Intensity Magnetic Separation of Iron Ores by *Ossi E. Palasvirta*—The apparently successful application of high-intensity magnetic separation in Germany to iron ore beneficiation has aroused considerable interest in the process in this country and Canada. The present paper contains a review of commercially available H.I.M. separators and discusses their relative merits in the light of results of laboratory investigation. A separator of optimum design is described with emphasis on the general layout of the magnetic circuit, pole piece and rotor design, materials of construction, and methods of operation. Slides are presented to illustrate the various design features.

The discussion of test results emphasizes the amenability of certain ores of simple mineralogy to high-intensity magnetic separation, but also pays attention to the difficulties encountered with ores of more complicated mineralogical make-up.

Ferrograde Concentrates from Arkansas Manganiferous Limestones by *M. M. Fine*—Extensive deposits of Arkansas manganiferous limestone are a potential source of ferrograde manganese concentrates. A beneficiation process comprising tabling, flotation, and leaching was developed by means of which ores analyzing less than 5 pct Mn were upgraded to 41.7 to 49.5 pct Mn. Recoveries ranged from 48.2 to 66.0 pct. 59B25.

Chemical Process: Nickel

Joint Session with Extractive Metallurgy Div. of The Metallurgical Society

Refining of Ni-Cu-Co Mattes by Pressure Leaching and Hydrogen Reduction by *R. F. Pearce, J. P. Warner, and V. N. Mackiw*—This paper is based on laboratory and pilot plant investigations which led to the development of a series of processes for production of high purity metals from Ni-Cu-Co mattes of a wide range of compositions.

The selection of ammonia or acid pressure leaching for various mattes is discussed. This is followed by discussion of various methods for leach solution purification and metal separation. The metals of high purity are produced by reduction with hydrogen from purified solutions.

Examples are given of complete flowsheets for a number of mattes. Drawing upon these examples, general principles for the selection of the most suitable treatment process for a particular material are outlined.

Under certain circumstances, these processes may replace part of the pyrometallurgical treatment and all of the electrolytic refining steps which are customary in the treatment of Ni-Cu-Co mattes. 59B41.

Modifications in Nicaro Metallurgy by *Armando Alonso and John Daubenspeck*—In the nickel extraction process at Nicaro, Cuba, dried and ground nickel-bearing laterites are reduced at 1300° to 1400°F in multiple hearth furnaces. Nickel is leached from the reduced ore by aeration in an aqueous solution of ammonium carbonate. Nickel carbonate is precipitated from the liquor and calcined to yield nickel oxide. The following are the more important modifications of the Nicaro process since plant rehabilitation and expansion.

An increase in tonnage of 15 pct was achieved without decreasing the fineness of the ore by minor mechanical modifications of the grinding plant. The new furnaces were built to withstand a maximum temperature of 1700°F for contemplated furnacing of serpentine and/or future lateritic ores of a more refractory nature. Controlled air addition to the reduction furnaces upper hearths burned formerly wasted combustibles thereby reducing oil consumption by 20 pct. A 50 pct increase in leach liquor cooling facilities alone provided a yearly increase in nickel production capacity of 5 pct. Stronger fresh leach liquor for increased nickel extraction was provided through improved distribution of water to ammonia absorption towers. Advantage was taken of the reduced ore property for precipitating cobalt, modifications in leach liquor circulation provided controlled cobalt solubility with minimum harm to nickel extraction.

Ammonium Sulfate Leaching—Hydrogen Reduction Process for Treating Nicaro Bulk Precipitate by *James Shea*—Nickel oxide produced at Nicaro must not contain cobalt in excess of 1 pct of its nickel content. To ensure this, operating conditions are set to repress cobalt solubility drastically. Under these conditions nickel solubility is slightly but significantly repressed. The GSA desired to increase nickel extraction. If this were done, however, too much cobalt would dissolve and the final product would fall outside the specifications for cobalt, unless a Ni-Co separation scheme were incorporated in the existing Nicaro process. The process in this paper has been designed as an adjunct to the Nicaro process, and provides an effective nickel-cobalt separation scheme The process calls for dissolving the Nicaro bulk precipitate in ammonium sulfate solution and treating the resulting pregnant liquor by a simplified version of the Sherritt Gordon process. The products would be high-purity nickel metal, a highly upgraded cobalt product, and a small tonnage of ammonium sulfate.

The results of the laboratory work described in this paper indicate the process is ready for continuous pilot-plant development work.

Symposium—Fatty Acid Flotation

The History of Fatty Acid Flotation by *George H. Roseveare*—Historically the art of recovering nonmetallic minerals by flotation developed at a later date than that of the sulfide minerals. Early experiments were not successful until the use of modifiers or conditioning reagents was developed to control the gangue minerals so that they would not float in soap flotation. Since that time many nonmetallic minerals have been treated successfully by soaps and detergents. 59B51.

Single Mineral Flotation with Linolenic, Linoleic, Oleic, and Stearic Acids by *Shiou-Chuan Sun*—This paper describes the relative effectiveness of four commonly known C-18 fatty acids, including linolenic, linoleic, oleic, and stearic acid, for the flotation of individual minerals. The test results of more than 20 minerals show that the collecting power of these acids is governed by: 1) the number of double bound of the acid, 2) the chemical composition of the minerals surface, and 3) the kind and amount of interfering ion in the mineral pulp.

Nonsulfide Flotation with Fatty Acid and Petroleum Sulfonate-Type Promoters by *S. A. Falconer*—Many different types of fatty acids and their soaps and sulfonated products, as well as other materials such as petroleum sulfonates, naphthenic acids, etc., have been extensively investigated for froth flotation for treating nonsulfide ores. The sources of some of these fatty acids and their chemical and flotation characteristics are briefly described in this paper.

With few exceptions, most of the commercially operating plants today are using either crude or refined oleic acid or tall oil or sulfonated petroleum oils as the principal promoter. Over the years, it has been found that these particular reagents possess the combined virtues of promoter efficiency and tolerable selectivity, together with reasonable cost, and ready availability.

The successful application of these preferred promoters depends upon a number of interrelated factors including: cleansing of mineral surfaces and desliming of the flotation feed when so required, avoidance of excess promoter, control of pH, proficient use of activating and depressing agents, proper choice of frother, effective conditioning of promoter and other reagents prior to flotation, etc. There is a need for greater specificity on the part of promoters for nonsulfide flotation. 59B38.

Feed Preparation and Mineral Coating in Fatty Acid Flotation by *Carl C. Martin and Burt C. Mariacher*—This article evaluates the methods of ore storage, crushing, grinding, and sizing in preparation for fatty acid flotation processes. The necessity for desliming of ores after grinding in various fatty acid flotation processes is discussed. The effects of blunging, temperature, conditioning, pH control, and water composition prior to flotation are discussed. The use of fatty acid alone for a collector, as compared to the artful use of fuel oils, petroleum sulfonates, phosphorates, poly-glycols, etc., in flotation operations, are described for mineral coating and froth control during roughing and cleaning steps in fatty acid concentration processes. 59B11.

Mill Design

Design Requirements For Tailing Disposal in the Southwest by *Edmond Vern Given*—This paper deals with the latest thinking for tailing dam design at some of the large concentrators in the southwest. It describes planning, design, construction, and operation. Although the paper carries the above title, it is believed that to adequately present design, some operation must (of necessity) be included. Embraced within the essay are ideas from some of the newer plants as well as some of the old established operations. Mention is made of the method developed at Morenci for distribution of tailing that is now being applied at several of the large mills. A brief run down is given on long-range planning, everyday construction, area required, operation with and without cyclones, water reclamation, etc., at the San Manuel Copper Corp., San Manuel, Ariz. There will be a few sketches showing beams, distribution manifolds, and cyclone installations—also piping arrangements for the tailing dams at San Manuel. 59B12.

Chemical Process: Uranium

Joint Session with Extractive Metallurgy Div. of The Metallurgical Society

Leaching, Ion Exchange, and Precipitation of Blind River Uranium Ores by *K. D. Hester, A. G. Roach, and R. P. Ehrlich*—This paper discusses the chemical aspects of the acid leaching, ion exchange, and precipitation circuits of some of the uranium mills in the Blind River area of Ontario, Canada.

For leaching, all the chemical variables are discussed and it is shown that high free acid concentrations and relatively high temperatures are required in order to obtain efficient recovery of the uranium. Graphs and tables show these results and operating costs are cited. Three different methods of purifying and concentrating of the uranium solution by means of ion exchange are discussed. Fixed bed columns, using an acid chloride elution system, are used at one plant. Fixed bed columns using an acid nitrate solution for elution are used at two plants, and moving bed columns using an acid nitrate solution for elution are used at four plants. All chemical results and reagent consumptions are discussed, with special reference to the problems encountered in each system.

For the precipitation circuit, two separate systems are discussed, one being the batch process using magnesium oxide as a precipitant, and the other one being a two-stage continuous process using lime and sodium hydroxide as a precipitant. Here again the chemical results and reagent consumptions are discussed.

The paper points out that, as far as the Blind River uranium ores are concerned, the largest single individual cost item is the reagents required in leaching, with the cost of ion exchange and precipitation being relatively low.

All these plants are designed for treating a relatively low grade ore compared to uranium deposits in the rest of Canada and the U. S. 59B28.

Union Carbide's Uranium Operation at Maybell, Colo. by *K. W. Lentz*—The paper describes briefly the history of the Maybell ore deposits and the work carried on prior to acquisition by Union Carbide Corp.

The design, engineering, and construction of the plant by Southwestern Engineering Co. for Union Carbide is discussed.

A rather complete description of the mill flow sheet is given with discussion of the equipment and metallurgy. The operation of the countercurrent resin-in-pulp circuit is described in detail.

The start-up organization, employe training program, and the problems encountered during start-up are also discussed. 59B7.

MINING & EXPLORATION DIVISION

Selected Geological Topics

Quantitative Mineralogy as a Guide to Exploration by *R. J. P. Lyon*—Studies made in various mining districts in the past have suffered from the basic inadequacy in the determination of fine grained alteration minerals under the microscope. An integrated approach to quantitative mineralogy is described by utilizing infrared absorption, X-ray diffraction, and differential thermal analysis. The application of these methods to the determination of the alteration of a small orthoclase phenocryst, the alteration envelopes surrounding veins in a piece of drill core, and the petrography of the standard G-1 and W-1 granite and diabase samples are discussed. The application to areal sampling problems in a serpentine belt, and as a guide to further drilling in a disseminated copper orebody with almost completely obscured outcrop, show the usefulness of quantitative mineralogy in exploration.

Tectonic Analysis as an Exploration Tool by *Peter Coles Badgley*—The first step is a study of major structural trends in basement complex for entire tectonic provinces. The major basement fabric once established exerts a strong control over all later deformational events (consequent tectonics). Many fracture systems are conjugate so that the basement mosaic frequently consists of wedge-shaped plates. When such plates move forward along boundary strike slip faults in response to post basement orogenic forces, new fracture systems are generated in the post basement cover rocks, creating excellent host areas for migratory mineralizing solutions. The apex regions of the wedges are particularly favorable. Forward movement of the wedges causes some of the stress to be transmitted to the adjoining plates of the basement mosaic, and secondary and tertiary fracture systems commonly develop in these adjoining areas. Forward moving wedges have been recognized at Butte, Pachuca, Central City, Kimberly, B.C., and in northwestern Quebec. Close study of these subsidiary fracture systems shows a genetic and spacial relationship which fits a definite time sequence for a single orogenic stress system. When every element of the structural fabric has been accounted for in terms of one or more stress applications, it becomes clear that there is a close relationship between features at both the district and regional level. A co-ordinated approach using both district and regional information provides a good background for future exploration of the entire tectonic province.

Genesis of the Scott Magnetite Deposit, Sterling Lake, N. Y., by *A. F. Hagner, L. G. Collins, and Tin Aye*—Magnetite occurs as layers in pyroxene amphibolite which has been replaced in varying degrees by gneiss and pegmatite. Since the country rock gneisses are interpreted as having formed by metamorphic and metasomatic processes, the associated magnetite bodies are also ascribed to these processes rather than to solutions from magmatic sources.

Fluorescent X-ray analyses of the biotite, hornblende, orthopyroxene, and clinopyroxene of the amphibolite show a decrease in iron content as the magnetite bodies are approached. Refractive indices and specific gravities of these minerals also decrease toward the ore bodies. Specimens from drill cores through relatively thick ore bodies show, in general, greater decreases in index than do those from core with smaller and fewer magnetite concentrations. Spectrographic analyses of three biotite specimens indicate that as iron decreases, manganese increases; this is substantiated by the trend in Fe/Mg ratios of 21 biotites determined by X-ray diffraction techniques.

It is believed that sufficient iron has been removed from the ferromagnesian silicates of the amphibolite to have supplied the iron in the magnetite bodies. During metamorphism and metasomatism, iron was expelled from the lattices of the mafic minerals and combined with oxygen to form magnetite. Differential movement along planar and linear structures in the amphibolite produced high and low pressure zones, and the iron migrated to the latter. In the low pressure zones magnetite has selectively replaced plagioclase, and each marked increase in magnetite percentage is accompanied by a comparable decrease in plagioclase percentage.

Deposits of Manganese Oxides by *D. F. Hewett*—Until X-ray analyses of minerals became available, there was considerable uncertainty in the identification of some of the manganese oxide minerals. During the war, in studying manganese deposits, geologists of the USGS collected many specimens of the ore minerals, especially the manganese oxides. The manganese minerals in about 250 specimens were determined by X-ray analyses by W. E. Richmond and J. M. Axelrod and many partial and complete chemical analyses were made by Michael Fleischer of the Geological Survey. Recently, the writer has reviewed the results of this work and by studying the geologic environment from which the specimens came, has tentatively classified 32 manganese oxides as to their supergene or hypogene origin.

It is concluded that the known manganese oxides fall into three genetic groups: 1) those which are probably supergene everywhere; 2) those which are probably hypogene everywhere; and 3) those which are supergene in some places and hypogene in other places. The review also indicates that many veins of manganese oxides, largely in tertiary volcanic rocks in the Southwest, are hypogene and are related genetically to deposits of stratified manganese oxides in tertiary sedimentary rocks in the same general region. It appears that hot waters from depth rose in fractures where they deposited manganese oxides and upon reaching the surface, the remaining manganese was precipitated as oxides which were carried to nearby basins and with other sediments deposited in stratified form.

Underground Mining I

The Seismic Wave From Plaster and Drill-Hole Explosive Charges by *Arthur W. Ruff*—The seismic wave from a confined drill-hole charge and also from an unconfined plaster charge consisted of a compression pulse followed by a tension pulse and a short train of compression and tension pulses. Tests indicated that, at equivalent distances of wave travel, the seismic wave from a confined charge had essentially the same shape as the seismic wave from a plaster charge.

A seismic wave with a high compression-strain maximum and a high time-integral of compression strain can be produced with no more confinement of the explosive charge than that provided by the rock, the explosive, and the atmosphere. The initial compression-pulse duration appeared to be approximately the same from plaster and drill-hole charges.

The amplitude of the initial compression pulse from a plaster charge increased with an increase in weight of explosive and also increased with an increase in strength of explosive. The difference between the compression-strain maximums for the high- and low-strength explosives remained constant even though the weight of the charge was varied. Therefore, the advantage of using a high-strength explosive rather than a low-strength explosive to produce the maximum compression strain decreased when larger charges were compared.

A method for determining an equation to predict the fragmentation to be expected in the rock tested is described. While the method is not yet usable, it is hoped that future work will make blasting effects predictable from the analysis of basic seismic-wave data.

Symposium: Exploration Problems

Geochemical Exploration in Silicated Limestone at Darwin, Calif. by *Carl Fulton Austin and Mathew P. Nackowski*—The paper to be presented is based on geochemical research carried out at the University of Utah. The field area was the Anaconda Co.'s Darwin Mines. The research was undertaken to determine the primary trace element distribution surrounding ore bodies in silicated limestones and to determine the possible application of geochemistry to prospecting for ore.

Case Histories—Exploration Ventures

The Bonanza Project, Bear Creek Mining Co. by *Douglas R. Cook*—Initiated by Bear Creek Mining Co. in 1952 and terminated in 1954, the project was based on the premise that the presence of concealed base metals in Paleozoic carbonate sediments would be reflected in the hydrothermal alteration of overlying pre-mineral volcanic rocks. Such an area, four square miles in extent of argillized, pyritized, silicified, and chloritized volcanic rocks is present in the southern Bonanza mining district, Colorado.

Geological, geophysical, and geochemical studies were followed by the diamond drilling of three holes totalling 6230 ft. Further alteration and geochemical studies were made

on the cores from these holes. A brief review of the alteration and geologic mapping, colored aerial photograph interpretation, geochemical soil and rock sampling, magnetometer, gravity, and scintillometer surveys will be presented together with some conclusions regarding this work. **59L18.**

COUNCIL OF ECONOMICS OF AIME

Appraisal of Paley Report

Expected Realignments in the Next Five Years by *Samuel G. Lasky*—It is popularly assumed that the Paley Commission made a variety of predictions regarding the supply and demand of materials in 1957. Actually, they did not; they made only projections that, in their judgment, indicated "the plausible shape of things in the decade 1970-1980." On that basis, the Paley record to now seems good. Gross national product and gross consumption of raw materials have closely followed the trend of the Paley projections. The cost of materials as a whole appears to be going up, as the Commission expected.

There is no reason as yet to change the Paley projections as they apply to supply and demand in general, although adjustments may be made for individual commodities as events dictate. Gross demand is certain to continue to grow substantially, accompanied by an upward pressure on real costs. But contrary to the Commission's fear that these costs may become so high as to create the "strong possibility of an arrest or decline in our standard of living," I foresee no difficulty in meeting this demand at costs that, though higher, will still be acceptable. **59K22.**

Role of the Mineral Engineer in Industrial Development and Area-Planning Programs by *H. W. Straley, III*—The field of mineral engineering is defined. The writer then points out that persons trained in this domain of knowledge may play an important part in the program of industrial development and area planning. This covers the whole range of activities from prospecting for new sources of raw materials through metallurgy, in all of which the sponsor and associates usually need guidance and counsel. Liaison, between specialists and clients or sponsors, is a most important part of the work of the mineral engineer. Appended is a short analysis of the possibility of employing one's own staff or engaging the services of private consultants or research institutes. It is concluded that large planning operations will usually find it most profitable to engage the last.

Role of Mineral Economics in Area Planning and Industrial Development by *John E. Husted*—The concepts of industrial development and area planning are defined and discussed, with emphasis on the part that a minerals study is given in such work. The implementation of such programs at the state, county and city level is reviewed and estimates of the costs and time are given. A thorough economic and technical analysis must be made in addition to a raw material availability study to justify the investment of money and to attract industry. The economic analysis should include: 1) transportation, 2) fuel costs and availability, 3) labor, 4) taxes, 5) markets, 6) competition, and 7) the interrelation of all available raw materials.

Technology covers requirements and specifications both for present and future needs. After the above information is prepared, minerals economics also enters the planning that will best adapt the resources of a given area to deficit markets, new technology, and changes in competition. Basic and satellite industries are then proposed where warranted. A final and important aspect of mineral economics is the education of the public to the realities of the minerals industry.

COUNCIL OF EDUCATION OF AIME

SME Education

Preregistration Counseling for Mineral Industries Students at Penn State by *John J. Schanz, Jr.*—Colleges offering training in the various fields of mineral science and engineering are faced with two problems: 1) attracting adequate numbers of competent young men to careers in the mineral industries, and 2) increasing the ratio of graduates to freshmen through effective selection and counseling. This latter problem will assume even greater significance when the rapid increase in the college-age population begins in the near future. If a larger percentage of students can be graduated, it will mean a smaller expansion of physical facilities and faculties to educate a larger number of students.

The larger number who do not graduate after entering The Pennsylvania State University can be attributed to inadequate general aptitude, lack of interest, curriculum misplacement, inadequate preparation, or poor performance. Through mandatory preregistration testing and counseling of all freshmen, Penn State is learning more about the student's aptitude, his interests, and his weaknesses in key subjects. With this information the university can direct the student toward the curriculum which offers the greatest promise.

The college of Mineral Industries, through its participation in this program, benefits in several ways. It receives students who are more likely to be truly interested in the field; it is able to detect students who need remedial work or who should be in less technical fields; and, incoming freshmen who have never heard about, or considered, a curriculum in the College obtain adequate information about them. **59J19.**

SOCIETY OF MINING ENGINEERS PROGRAM

Program data is complete as of October 20. Further changes and up-to-date information will appear in January. Numbers after paper listings indicate available preprints—see page 1241.

COAL DIVISION

Session I

1) Hydraulic Mining of Gilsonite and Its Application to Coal Mining: *J. H. Baker*, American Gilsonite Co. **59F3.**
2) Faults—In Pitching Coal Seams—Their Effect on Mining and Their Solution: *Robert H. Carpenter*, Colorado School of Mines, and *Albert M. Keenan*, Thompson Creek Coal & Coke Co.
3) Reducing the Bounce Hazard at Sunnyside: *L. P. Huntsman*, Kaiser Steel Corp.

Session II

1) Maximum Efficiency and Recovery vs Cost: *James D. Reilly*, Hanna Coal Co.
2) Cleaning Plant Design for Minimum Operating Labor: *J. D. Price* and *William M. Bertholf*, Colorado Fuel & Iron Co. **59F5.**
3) Design for Minimum Maintenance Labor and Supplies: *Albert P. Massman*, Peabody Coal Co.

Session III

1) Wellington Preparation Plant: *Loring McMorris*, Columbia Geneva Steel Co.
2) Characteristics of Coal Preparation Plant Slimes: *H. B. Charmbury* and *D. R. Mitchell*, Pennsylvania State University.
3) A Laboratory Investigation of Flocculation as a Means of Improving Filtration of Coal Slurry: *M. R. Geer, P. S. Jacobsen*, and *H. F. Yancey*, Div. of Solid Fuels Technology, U. S. Bureau of Mines. **59F34.**

Session IV

1) Communication System at an Extensive Arizona Copper Mine: To be announced.
2) Are Mine Employes and Dollars Protected As Well As Industrial Employes and Dollars From Fire?: *Ward Stahl*, U. S. Bureau of Mines. **59F26.**
3) An Investigation of Materials Used For Stoppings In Coal Mine Ventilation Systems: *Charles T. Holland*, Virginia Polytechnic Inst., and *W. J. Skewes*, Pocahontas Fuel Co.
4) Safety With Continuous Miners In Steeply Pitching Coal: *L. H. McGuire*, U. S. Bureau of Mines.

Session V

1) The Advantages of AC Distribution In Mining Service: *Wendell C. Painter*, Joy Manufacturing Co.
2) AC Power Distribution For Underground Mining: *W. B. Jamison*, Jamison Coal Co.
3) The Automation of Mining: *Gerald von Stroh*: Bituminous Coal Research Inc.

Session VI

1) What Can Be Expected From Coal Research?: *T. Reed Scollon*, U. S. Bureau of Mines. **59F43.**
2) Removal of Sulfur Dioxide From Flue Gases At Elevated Temperature: *Joseph H. Field* and *Daniel Bienstock*, U. S. Bureau of Mines. **59F24.**
3) Coal Characteristics and Their Relationship To Combustion Techniques: *T. S. Spicer*, Pennsylvania State University.
4) The Integration of Coal Characteristics With The Design of Large Pulverized Coal Boilers: *Douglas G. Hubert*, Combustion Engineering. **59F30.**

Session VII

1) The Coal Pipeline: *V. D. Hanson* and *T. J. Regan*, Consolidation Coal Co.
2) Coke Combustibility—A Neglected Characteristic: *J. D. Price*, Colorado Fuel & Iron Co. **59F6.**
3) To be announced: *A. H. Brisse*, U. S. Steel Corp.

INDUSTRIAL MINERALS DIVISION

Ceramic Raw Materials

1) Paper on missile nose cones.
2) To be announced.
3) Clay Basins of the Pacific Coast States: Moderator —*R. F. Brooks* Gladding McBean & Co.

Chemical Raw Materials

1) The Grand Isle Mine, Freeport Sulphur Co.'s Off-Shore Venture: *Z. Wilson Bartlett, C. O. Lee,* and *R. H. Feierabend,* Freeport Sulphur Co.
2) Fluorspar for Water Treatment: *F. J. Maier,* U. S. Public Health Service.
3) Paper on potash: *A. V. Mitterer,* International Minerals & Chemical Corp.
4) Recovery of Phosphates by In Situ Fluid Mining: *Sylvain J. Pirson,* The University of Texas. **59H4.**
5) Colemanite as an Important Source of Borates: *William T. Griswold,* Kern County Land Co. **59H20.**
6) Potash in Saskatchewan: *Marion A. Goudie,* Winsal of Canada Ltd. **59H16.**

Rare and Radioactive Minerals

Joint Session with IndMD and SEG

1) Geology of the Montgary Pegmitite: *Richard W. Hutchinson,* Toronto. **59H46.**
2) Environmental Factors Governing the Origin and Distribution of Heavy-Mineral Deposits on Padre Island, Texas, A Barrier Island: *Louis Moyd,* Consulting Geologist.
3) Thorite and Rare Earth Deposits in the Lemhi Pass Area, Lemhi County, Idaho: *Alfred L. Anderson,* Cornell University.
4) Radiographic Distribution Analysis Applied to Uraniferous Pyrite, Galena, and Sphalerite: *H. D. Wright, J. J. Hutta, W. P. Shulhof,* and *C. M. Smith,* Pennsylvania State University.
5) Economic Uranium Deposits in Granitic Dykes, Bancroft District, Ontario: *S. C. Robinson,* Geological Survey of Canada.

Water Problems

3) Water Law as Related to Dredging in Idaho: *Robert P. Porter, Richard B. Porter,* and *Robert A. Lothrop,* Porter Brothers Corp. **59H9.**
2) Land Subsidence in the San Joaquin Valley, Calif.: *J. F. Poland,* U. S. Geological Survey.
3) Water Law and Its Significance to the Mining Industry: *Wells A. Hutchins,* U. S. Dept. of Agriculture. **59H1.**
4) Relation of Land Subsidence to Ground-Water Withdrawals in the Upper Gulf Coast Region, Texas: *A. G. Winslow* and *Leonard A. Wood,* U. S. Geological Survey. **59H2.**

Special Sands and Abrasives—Fillers, Fibers, and Pigments

1) Rapid Method for Determining Feldspar Content in Felspathic Sands: *Hugh H. Bein,* Del Monte Properties. **59H8.**
2) Marketing Trends for Selected Mineral Fillers: *W. F. Dietrich,* U. S. Bureau of Mines.
3) Diatomite—A Current Review: *Arthur B. Cummins,* Johns-Manville Corp.
4) Man-Made Industrial Diamonds: *J. D. Kennedy,* General Electric Co.
5) To be announced: *Thomas D. Murphy,* Pennsylvania Glass Sand Corp.

Cement, Lime, and Gypsum—Mineral Aggregates—Dimension Stone and Slate

1) Franciscan Chert in California Concrete Aggregates: *Harold B. Goldman,* California Div. of Mines.
2) Aggregate in California: *T. E. Gay, Jr.,* California Div. of Mines.
3) Modern Classification Methods Applied to Fine Aggregates: *C. E. Golson,* Western Machinery Co.
4) Flow of Limestone and Clay Slurries in Pipelines: *Ross W. Smith,* Colorado School of Mines Research Foundation Inc. **59H14.**
5) CO_2 Gas as Slurry Thinner: *Duncan Williams* and *Harold Potter,* Monolith Portland Midwest Co. **59H15.**
6) Measurement of Cement Kiln Temperatures: *N. C. Ludwig* and *R. E. Boehler,* Universal Atlas Cement Co.

MINERALS BENEFICIATION DIVISION

Crushing and Grinding

1) The Gyratory Ball Mill, Its Design, Principle of Operation, and Performance: *A. W. Fahrenwald,* Moscow, Idaho. **59B35.**
2) Crushing Practice at Silver Bay Taconite Plant: *A. S. Henderson, E. M. Furnace,* and *F. E. MacIntire,* Reserve Mining Co.
3) Pebble Milling Practice in the Reduction Works of the Gold Mines of Union Corp. Ltd.: *O. A. E. Jackson,* Union Corp. Ltd. **59B17.**
4) To be announced.

Solids-Fluid Separation

Symposium: Theory, Design, and Operation of Countercurrent Decantation

1) Countercurrent Decantation—When and Why?: *Elliott J. Roberts,* Dorr-Oliver Inc.
2) To be announced: *R. R. Porter,* Salt Lake City.
3) Thickening Leach Residues in the Sherritt Gordon Nickel Refinery: *D. J. I. Evans* and *S. C. Lindsay,* Sherritt Gordon Mines Ltd. **59B37.**
4) Separation and Washing of Alumina Process Residue: *Morton Handelman,* Reynolds Metals Co. **59B10.**

Materials Handling

1) The Wobbler Feeder: *T. A. Oberhellmann,* Hammermills, Inc.
2) Flow of Bulk Solids—Progress Report: *A. W. Jenike, P. J. Elsey,* and *R. H. Woolley,* Utah Engineering Experiment Station, University of Utah.
3) Belt Conveyor Power Studies: *A. W. Asman,* Hewitt-Robins Inc.
4) Stockpiling Purposes, Methods, and Tools: *Lawrence O. Millard,* Link-Belt Co.

Concentration

1) Scrubbing of Mesabi Range Intermediate Iron Ores: *William R. Van Slyke,* Cleveland Cliffs Iron Co., and *R. C. Ferguson,* Hardinge Co.
2) Consideration of Practical Ore Dressing Problems That Are Seemingly at Variance with the Theoretical: *C. J. Veale,* The Fresnillo Co.
3) Two Years Milling at Bicroft Uranium Mines Ltd.: *D. F. Lillie, W. J. Dengler,* and *I. C. Edwards,* Bicroft Uranium Mines Ltd.
4) High-Intensity Magnetic Separation of Iron Ores: *Ossi E. Palasvirta,* U. S. Steel Corp.
5) Ferrograde Concentrates from Arkansas Manganiferous Limestone: *M. M. Fine,* U. S. Dept. of the Interior. **59B25.**

Chemical Process: Nickel

Joint Session with Extractive Metallurgy Div. of The Metallurgical Society

1) Refining of Ni-Cu-Co Mattes by Pressure Leaching and Hydrogen Reduction: *V. N. Mackiw, R. F. Pearce,* and *J. P. Warner,* Sherritt-Gordon Mines. **59B41.**
2) Co-Ni Separation—An Investigation of the De-Merre Process: *D. W. Bridges.*
3) Modifications in Nicaro Metallurgy: *Armando Alonso* and *John Daubenspeck,* Nickel Processing Corp.
4) Pressure Leaching and Electrowinning of Colbalt at the Garfield Refinery of the Calera Mining Co.: *J. S. Mitchell,* Calera Mining Co.
5) Ammonium Sulfate Leaching-Hydrogen Reduction Process for Treating Nicaro Bulk Precipitate: *Jim Shea,* Battelle Memorial Inst.

Symposium: Fatty Acid Flotation

1) The History of Fatty Acid Flotation: *George H. Roseveare*, Arizona Bureau of Mines. **59B51.**
2) Single Mineral Flotation with Linolenic, Linoleic, Oleic, and Stearic Acids: *Sciou-Chuan Sun*, Pennsylvania State University.
3) Nonsulfide Flotation with Fatty Acid and Petroleum Sulfonate-Type Promoters: *Stuart A. Falconer*, American Cyanamid Co. **59B33.**
4) Feed Preparation and Mineral Coating in Fatty Acid Flotation: *Carl C. Martin*, and *Burt C. Mariacher*, Colorado School of Mines Research Foundation Inc. **59B11.**

Mill Design

1) To be announced: *John Blackshaw*, Holliger Consolidated Gold Mine.
2) Design Requirements for Tailing Disposal in the Southwest: *E. Vern Given*, San Manuel Copper Corp. **59B12.**
3) To be announced.
4) To be announced.

Chemical Process: Uranium

Joint Session with Extractive Metallurgy Div. of The Metallurgical Society

1) Leaching Ion Exchange and Precipitation of Blind River Uranium Ores: *K. D. Hester, A. G. Roach*, and *R. P. Ehrlich*, Rio Tinto Management Service. **59B28.**
2) Kinetic Study of the Dissolution of UO_2 in H_2SO_4: *T. L. Mackay* and *M. E. Wadsworth*, University of Utah. **59B42.**
3) Working the Kinks Out Of the Homestake-New Mexico Partners Mill: *Clyde W. Garman.*
4) Union Carbide's Uranium Operation at Maybelle, Colo.: *K. Lentz*, Union Carbide Corp. **59B7.**

MINING AND EXPLORATION DIVISION

Selected Geological Topics

1) Quantitative Mineralogy as a Guide to Exploration: *R. J. P. Lyon*, Kennecott Copper Corp.
2) Tectonic Analysis as an Exploration Tool: *Peter C. Badgley*, Colorado School of Mines.
3) Genesis of the Scott Magnetite Deposit: *A. F. Hagner, L. G. Collins*, and *Tin Aye*, University of Illinois.
4) Deposits of Manganese Oxides: *D. F. Newett*, U. S. Geological Survey.
5) Geochemical Study of Pb-Zn-Ag Ores. Dawn Mine, Inyo County, Calif.: *Wayne E. Hall*, U. S. Geological Survey. **59I47.**

Underground Mining I

1) Underground Mining Methods at Gaspe Copper Co., Quebec, Canada: *William Brissenden*, Gaspe Copper Co.
2) Long Hole Drilling as an Aid to Mining Pb-Zn Ores of the Park City, Utah District: *G. W. DeLamare*, United Park City Mines Co.
3) The Seismic Wave from Plaster and Drill Hole Explosive Charges: *Arthur Ward Ruff*, Cananea Consolidated Copper Co.
4) To be announced.

Underground Mining II

1) Ambrosia Lake Mining Problems: To be announced, Homestake-Sapin Co.
2) Pillar Recovery at the Mi Vida Mine: *Virgil Bilyou*, Mi Vida Mine.
3) To be announced.
4) To be announced.

Health, Safety, and Personnel

1) Safety and Industrial Hygiene at Braden Copper Co., Chile: *Stanley M. Jarret.*
2) To be announced.
3) To be announced.
4) To be announced.

Symposium: Exploration Problems

1) Geochemical Exploration in Silicated Limestone at Darwin, Calif.: *Carl Fulton Austin*, and *Matthew P. Mackowski.*

Panelists

1) Management: *James Boyd* and *C. White*
2) Government: *C. Anderson* and *J. Harrison*
3) Geology: *H. Schmitt* and *C. P. Jenney*
4) Geophysics: *G. Rogers* and *H. Seigel*
5) Geochemistry: *H. E. Hawkes* and *J. Riddell*

Geophysics

1) Relation of Magnetic Anomalies to Some Geologic Structures in Northern Minnesota: *Gordon D. Bath.*
2) Aeromagnetic Efforts of Igneous Features of Northern Minnesota: *George D. Schwartz.*

Geochemistry

1) Geochemical Study of Pb-Ag-Zn Ore from the Darwin Mine, Inyo County, Calif.: *Wayne E. Hall.*

Case Histories—Exploration Ventures

1) The Bonanza Project, Bear Creek Mining Co.: *Douglas R. Cook*, Bear Creek Mining Co. **59L18.**
2) To be announced: *D. Salt.*
3) Mattagami-Quebec: *C. P. Jenney.*
4) Esperanza Orebody, Arizona: *H. Schmitt.*
5) Anaconda Exploration in the Bathhurst District of New Brunswick: *C. G. Cheriton*, The Anaconda Co. Ltd.

COUNCIL OF ECONOMICS OF AIME

Appraisal of Paley Report I

1) Copper, Lead, and Zinc: *Evan Just.*
2) The Light Metals: *Walter Rice*, Reynolds Mining Corp. **59K31.**
3) Industrial Minerals: *Raymond B. Ladoo*, Consulting Engineer. **59K23.**
4) Iron and Steel: *John D. Sullivan*, Battelle Memorial Inst. **59K48.**
5) Energy Sources: *Eugene Ayres*, Gulf Oil Corp.

Appraisal of Paley Report II

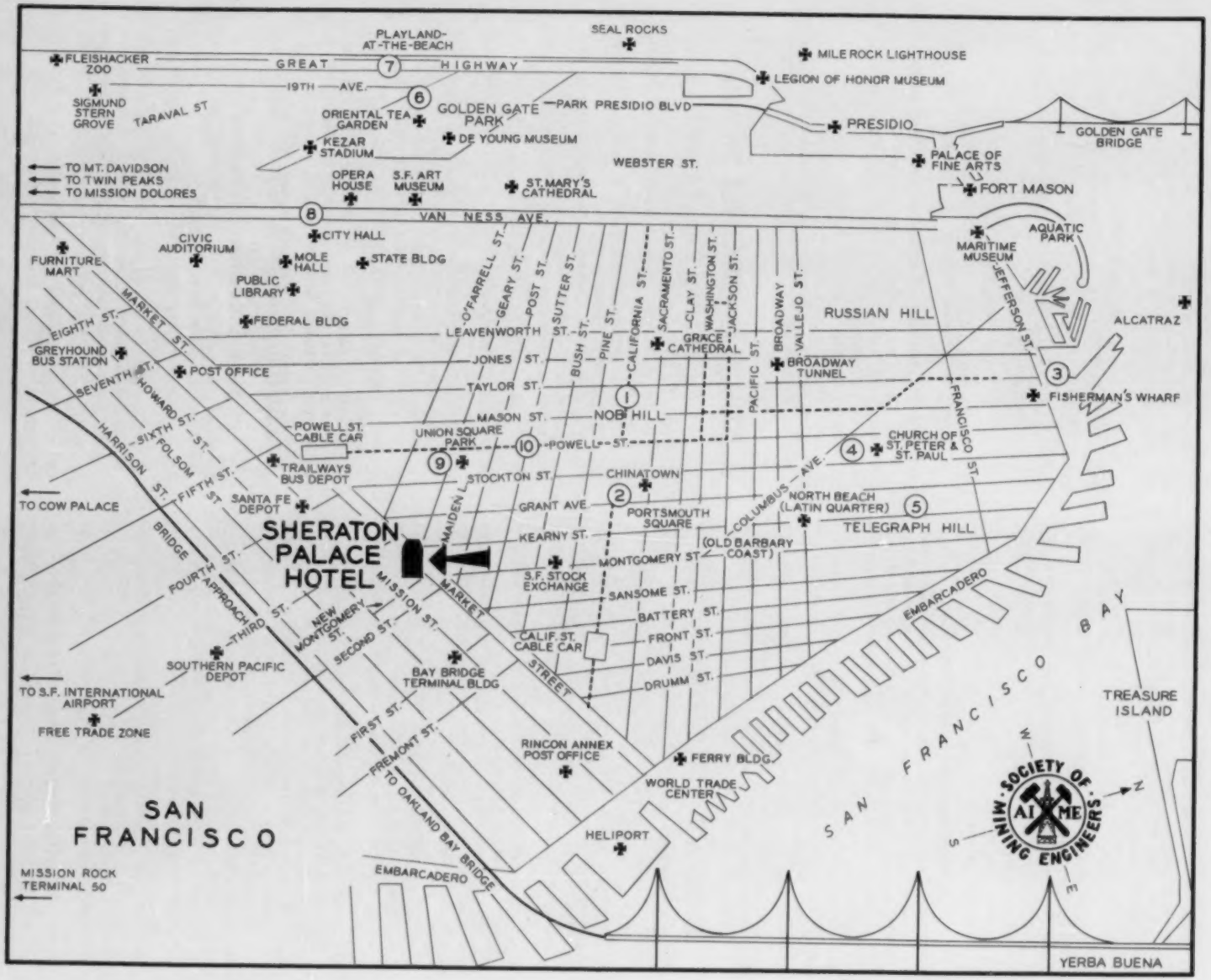
1) Expected Realignments in the Next Five Years: *Sam Lasky*, U. S. Dept. of Interior. **59K22.**
2) The Role of the Mineral Engineer in Industrial Development and Area-Planning Programs. *H. W. Straley, III*, Georgia Inst. of Technology.
3) The Role of Mineral Economics in Area Planning and Industrial Development: *John E. Husted*, Georgia Inst. of Technology.
4) Trends in Real Prices of Representative Minerals Commodities, 1890-1958: *Charles W. Merrill*, U. S. Bureau of Mines. **59K21.**

COUNCIL OF EDUCATION OF AIME

SME Education Committee

Symposium: The Future of the Mineral Industries and the Educational Requirements for Its Engineers

1) Exploration Developments: *Arthur Brant*, Newmont Exploration Ltd.
2) Developments in Mining: *Roger V. Pierce*, Consulting Mining Engineer.
3) Problems and Developments in Mineral Beneficiation *Norman Weiss*, American Smelting & Refining Co.
4) Changing Demands for Raw Materials: *F. C. Kruger*, International Minerals & Chemical Corp.
5) Preregistration Counseling for Mineral Industry Students at Penn State: *J. J. Shanz*, Pennsylvania State University. **59J19.**



Courtesy Welcome Map Publishing Co., San Francisco

MINING ENGINEERING Directory For SME's San Francisco

For Your Information—

February mean temperature, 53°F; humidity, 72; rainfall, 4 in.; percentage of possible sunshine, 57.

Tours of San Francisco can be arranged. Ask at the desk in the Sheraton-Palace.

Travel in downtown San Francisco by cabs, cable cars, sight-seeing buses, or cars with guides. A "Downtown Shoppers Shuttle" operates daily 10:30 am to 3:30 pm. Motor bus flying yellow flags; fare, 5¢. Service 5 min apart on continuous circuit: Second at Market, up Post to Stockton, down Stockton to Market, out Market to Hayes, around Civic Center, back on Polk to Market, down Market to Second St. (leaves near Sheraton-Palace Hotel—one block southeast).

Recommended Restaurants

(Type of food indicated; and address and telephone number given).

Adolph's (Italian), 641 Vallejo, EX 2-6333.

Bardelli's (San Francisco), 243 O'Farrell, YU 2-0243.

Kuo Wah Cafe (Chinese), 950 Grant Ave., YU 2-1851.

Nam Yuen (Chinese), 740 Washington.

New Delmonico (American, European), 330 Sutter, SU 1-4262.

Omar Khayyam's (American, European), 196 O'Farrell, SU 1-1010.

San Remo (American, Italian), 2237 Mason, TU 5-9657.

Shanghai Low (Chinese), 532 Grant Ave., YU 2-2008.

Skipper Kent's (Oriental), Columbus and Taylor, PR 6-3737.

Taj of India (Indian), 825 Pacific, EX 2-0089.

Tao Tao (Chinese), 675 Jackson St., YU 2-6125.

Tokyo Sukiyaki (Japanese) Jefferson at Taylor, PR 5-9030.

Fisherman's Wharf Restaurants: Alioto's Seafood Grotto, DiMaggio's, Exposition Fish Grotto #1, Fisherman's Grotto, Franciscan, Lighthouse Seafood Grotto, Mario's at the Wharf, A. Sabella Fish Grotto, Sabella and La Torre, Tarantino's, Waikiki.

Other AIME Hotels

9) St. Francis (Powell at Geary, YU 6-2131), headquarters for The Metallurgical Society.

10) Sir Francis Drake (Powell at Sutter, EX 2-7755), headquarters for the Society of Petroleum Engineers.

Scenic Attractions

1) First for a panoramic view of San Francisco Bay, Golden Gate Bridge, the ocean, and the myriad city, visit the **Top O' the Mark.** Located on Nob Hill, the Mark Hopkins Hotel is one of several impressive hotels bearing the names of early gold, silver, and railroad barons who built their mansions on that site.

2) Just below is **Chinatown,** famed settlement of oriental culture claiming to be the largest outside Asia. The bright pagoda roofs and exotic bazaars offer tempting curios for tourists and surprising Cantonese delicacies for gourmets. Go to Nam Yuen or Kuo Wah Cafe for authentic Chinese cuisine.

3) Take a cable car to **Fisherman's Wharf,** the **Aquatic Park,** and **Maritime Museum.** Miles of roller-coaster thrills, scenic splendor, and chiming bells cost only 15¢! Board the square-rigged windjammer **Balclutha** at the museum; watch the fishermen mending nets and unloading live crabs from tiny sea-going vessels; and stop for a fresh-caught meal cooked in sidewalk cauldrons, or splurge at the tropical delight, Skipper Kent's.

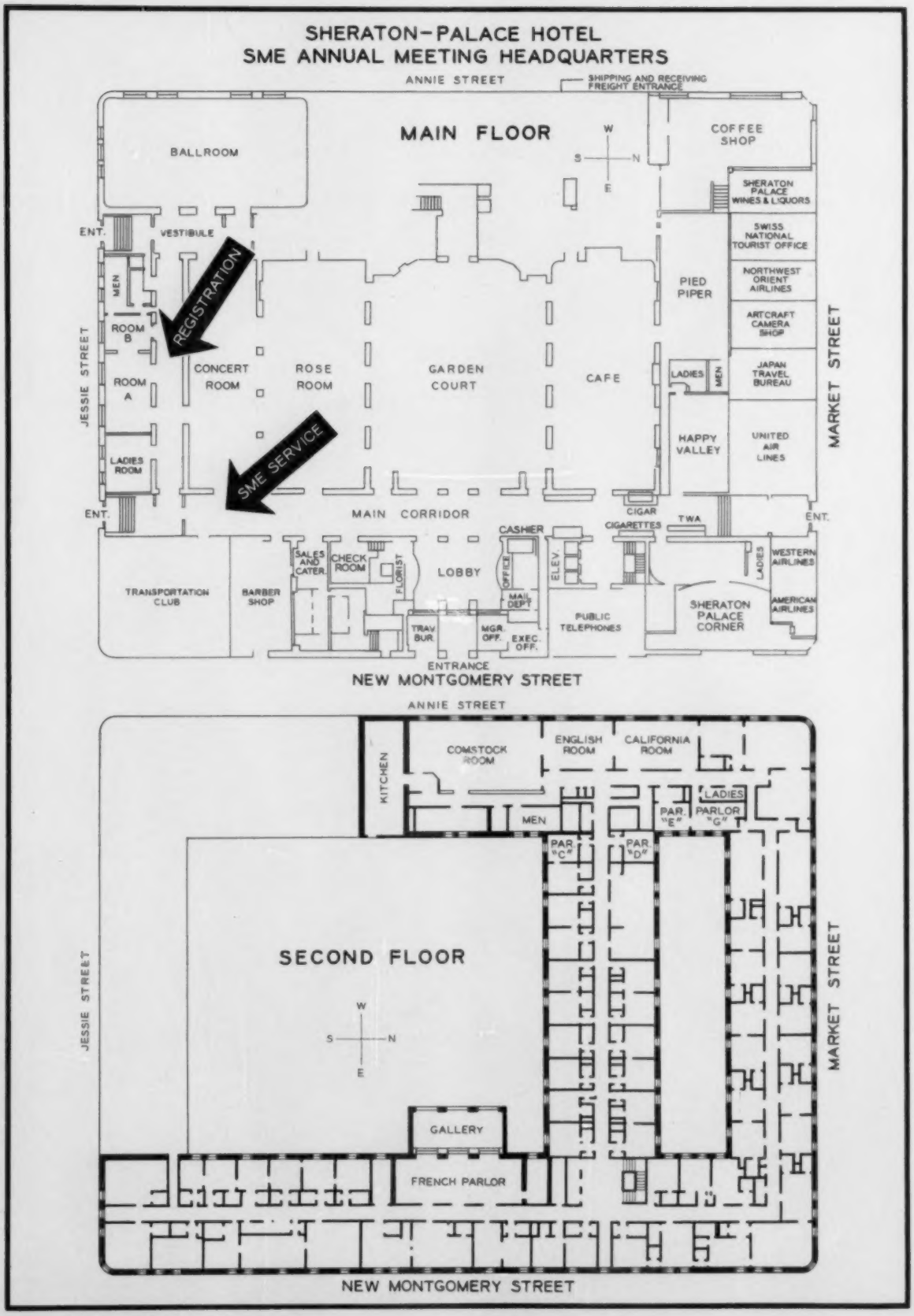
4) Visit the **Church of Saints Peter and Paul** where annually a procession starts the colorful ceremonies of blessing the fishing fleets. In the heart of bohemian North Beach, or **Little Italy,** the streets are pungently filled with the aroma of wine and cheese, pastes and sausages of the French, Spaniards, Basques, and Italians who live in this Latin Quarter.

5) For another sweeping view, climb the precarious alleys leading from the quarter to **Russian Hill** or **Telegraph Hill.** An old Russian burial ground and the homes of writers and artists cover one peak. The Coit Tower tops the other, a memorial to the volunteer firemen, built by the bequest of Lillie Hitchcock Coit who was a company mascot when she was a little girl.

6) A city of sea and of hills, San Francisco is also a city of parks. **Golden Gate Park** offers all sports from polo to golf, plus tropical conservatories, the Steinhart Aquarium, and the famed De Young Museum.

7) Beaches and forests, the Great Highway, and the historic Cliff House restaurant are nearby for **scenic country sight-seeing.** Lovely old Missions founded by the Spaniards combine Moorish, Mission, and Corinthian styles of architecture. Mission Dolores contains decorations and paints brought from Spain, though Indian converts painted the timbers and covered the roofs with tile.

8) The city itself is probably proudest of its marble and granite monuments comprising **Civic Center.** The Opera House, Art Museum, City Hall, and Civic Auditorium are gathered here to house international conferences and other historic meetings, and to epitomize the vigorous, progressive spirit of San Francisco that the world sees symbolized in its gleaming, famous bridges.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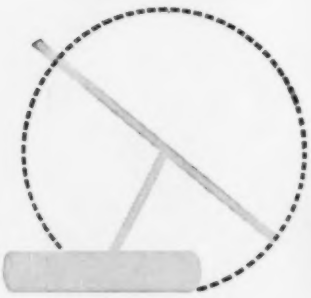

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NOTES ON POTASH PRODUCTION

A casual discourse on a growing business, which has about doubled in the past ten years. Where is it going?

by J. MARSHALL DOWNEY

The most fortunately situated U. S. potash producer—whether in New Mexico, California, or Utah—once simply took from the ground a mixture of sodium chloride and potassium chloride, crushed it to a maximum of 10 mesh, and separated the two salts by physical methods. He piled the sodium chloride on the desert and sold the potassium chloride to fertilizer mixing companies.

Seven companies in the Carlsbad basin of New Mexico now use at least three basic processes for making the separation and at least three more processes have been or are under investigation. In addition, two companies outside the basin use two methods for taking KCl from natural brines.

Minor amounts of other salts of potassium are made by chemical and quasichemical methods. These salts supply a special fertilizer market which cannot tolerate chloride—potassium sulfate is prominent in this category.

Change in Potash Market: During the past four years supply has temporarily caught up with demand as the number of operators in the field has rapidly increased. Due to change in supply of potash compounds the cheapest refining process is no longer necessarily the best. Buyers are quite selective and physical characteristics of potash salts—particularly those of muriate—determine their saleability. Physical characteristics desirable in some cases are uniformity of particle size within a number of size ranges and absence of entrained foreign materials (iron and silica).

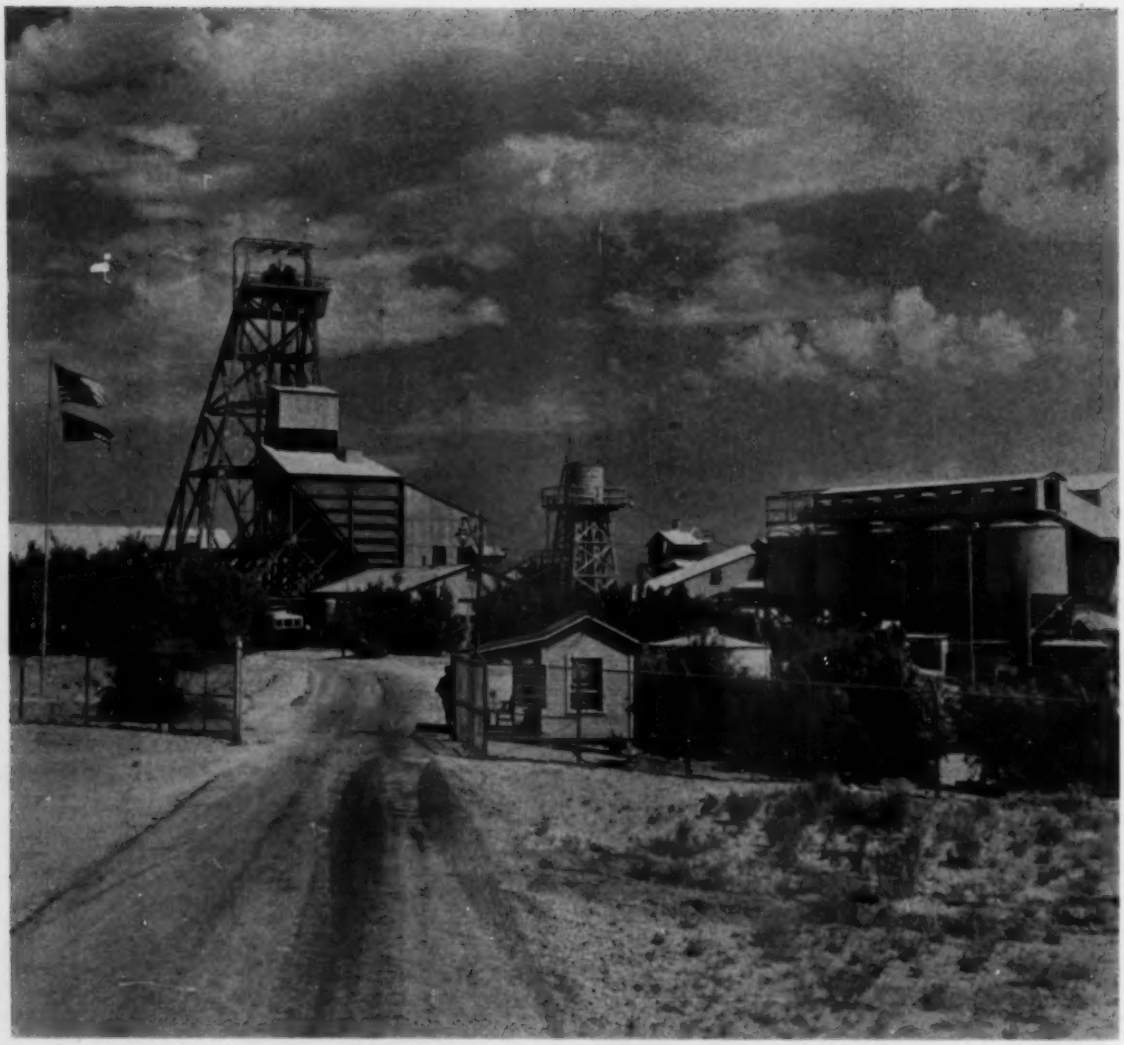
These specifications have brought the crystallizer back as a tool for purifying KCl. For a time, between 1950 and 1954, when there was still a hungry market for potash, crystallization threatened to become uneconomical because of its high cost in comparison with the very excellent flotation method which could be applied to produce coarse sylvite.

To make an orderly survey of a potash establishment, one should first consider a virgin deposit. New Mexico's Carlsbad Basin, for example, is in a shallow lagoon of the great ocean of evaporites of the Permian Basin. The strata dip gently east and terminate on the west in a ragged line roughly parallel to and a few miles east of the Pecos River in Eddy and Chaves counties. The first five companies to develop the area—from United States Potash Co. (1931), to Southwest Potash Corp. (1952)—located on deposits within a north-south strip about 10 miles wide and 30 miles long, centered about 15 miles east of Carlsbad. Later companies, National Potash Co. and Farm Chemicals Resources Corp., expanded the field east about 15 miles (the latter is not yet operating).

The evaporites are predominantly halite (NaCl). The salt is divided horizontally by beds of anhydrite, which are continuous for miles and serve as marker beds for locating horizons. The sulfates vary from traces to many feet thick and grow in number and thickness near the bottom of the salt beds to eventually form an impervious floor. Polyhalite, a triple salt of calcium, magnesium and potassium, and the first potash mineral to be recognized in the beds, replaces the anhydrite toward the middle and top zones. The word *replace* is used in the layman's sense generally but is also technically correct in places. Sylvite (KCl), occurs in numerous well-defined beds mixed with the halite.

At present only one of the sylvite beds is mined in Eddy County, where the first five mines in the field are located. The sixth, National Potash Co., is located in Lea County, east of Eddy County and mines sylvite from a relative, higher horizon. The seventh company, Farm Chemical Resources Corp., also has sylvite reserves in this higher horizon. The lower bed is not economical in the Lea County locations.

J. M. DOWNEY is Research Engineer, Southwest Potash Corp., Carlsbad, N. M.



The usually stable U. S. potash industry, its markets growing with the population, must meet growing competition.

In addition to these sylvite deposits, a deposit of langbeinite, a double sulfate of magnesium and potassium, occurs in a good bed about 100 ft above the main sylvite deposit in the land occupied by International Minerals & Chemical Corp. IMC mines this langbeinite also and from it produces potassium sulfate and the mixed sulfate for use as special fertilizer. Others produce sulfate synthetically.

Mining Methods: Potash mining is superficially like coal mining. The ore is soft enough to be drilled with augers like coal, and the bed deposits make it logical to choose coal type transportation equipment and mining systems.

Potash, however, is cleaner, safer, and tougher than coal. Only dynamite gives adequate fragmentation. There are no distinct stratum boundaries to the ore zone, although miners can generally identify the ore limits by color and texture. Some continuous mining machines are being operated but they are of much heavier construction and somewhat different design than standard continuous coal miners. Most of the design alteration has been done, at some cost, by the potash companies.

Ore brought from the mine is crushed and ground to essential mineral particle liberation at about 8 to 20 mesh. There is no sacred way of doing this. A wide variety of mills and sizing devices, both wet and dry, with various circulating loads, are successfully used.

The Carlsbad companies mine potash at widely different rates, which vary from about 3500 to 12,000 tpd of ore. Grades vary from 12 to 25 pct K_2O, or about 19 to 40 pct KCl. Some of the higher grade ore is mined by U. S. Potash Co., div., U. S. Borax & Chemical Corp. and is refined by crystallization. Most of the other companies use crystallization only to increase recovery, upgrade flotation concentrates, and to produce relatively small quantities of industrial grade KCl. U. S. Potash was first in the field and adopted crystallization for purification because it was then the most practical method available. Potash Co. of America pioneered flotation as a tool for

Biggest of the new world potash sources are located in Canada. This Saskatchewan operation plans 1960 production.

refining and has continued to use the same basic system, with improvements, from the middle thirties to the present.

Soap Flotation: The classical PCA method is to pretreat with heavy metal ion and use long chain organic anion in a true soap to float finely ground halite from potash. Although amine flotation has some advantages over soap flotation in potash mills, the PCA method was a bold idea when it was introduced. At one time it might have been thought comparable to trying to float galena or sphalerite in a solution saturated with soluble lead or zinc salts. The surface mechanism is, of course, quite different from that in sulfide flotation, but it took a brave man to first suggest it and an extremely optimistic man to try it.

After soap flotation became a reality, other reagents were tried and amine flotation was adopted by Union Potash Co. (later absorbed by International Minerals & Chemical Corp.) Companies that came into the field after International also employed amine flotation.

Crystallization: In refining Carlsbad Basin potash by crystallization, the mined ore is crushed to a size convenient for handling and rapid dissolving, and placed in a hot brine saturated with NaCl, but not saturated with KCl. The sylvite is dissolved and the insolubles, including salt, are filtered out. The clear, hot brine saturated with both KCl and NaCl is cooled. The KCl drops out of the solution but the NaCl remains dissolved. This occurs because solubility of KCl increases with temperature and that of NaCl does not when the brine is saturated with KCl. NaCl, in fact, becomes slightly less soluble at the higher temperatures in these brines, and the system is thus ideal for high grade KCl production. The KCl is filtered from the cooled slurry, and the filtrate is heated and recycled to pick up potash from more ore.

Amine Flotation: The greatest tonnage of potash

is produced by amine flotation. Unneutralized amine is not used because a salt such as the chloride or acetate is easier to handle and is more efficient. The amine used is a mixture of straight chain 12 to 20-carbon primary amines. It is generally fed to the circuit as a salt in a water solution (or a colloidal sol) of less than one to more than 4 pct strength.

The notorious potash slimes must always be discussed with amine flotation. These clay slimes contain a large percent of montmorillonite clay, which is highly negative and sponge-like in soaking up the positive amine ion. Even in well-deslimed ore, most of the amine fed to the circuit is consumed in slime. This consumption is minimized to an economical extent by a variety of clay-blocking agents, but, in spite of these agents, amine consumption in potash would be fractional if the reduced clays were not present. Interestingly, these reduced clays are predominant mostly in the high grade sylvite zones.

Another novel character that appears only in these zones is blue halite, which is said to be colored by a colloidal dispersion of reduced elemental sodium. Physical chemists have produced so-called color centers in alkali halides in the laboratory by turning gamma rays and X-rays on normal halides. It is not inconceivable, therefore, that the elemental sodium and the strongly negative (reduced) clay were both caused by the radioactive isotope of potassium present in the potash. The radioactivity can easily be detected by an ordinary radiation counter and is used by some of the companies in assaying for potash.

Considerable spending for desliming can be justified because pure montmorillonite will absorb, by base exchange, about 100 milliequivalents of amine per 100 g of clay. In an ore containing 1.0 pct clay, half of which is montmorillonite, this amine consumption would be about 2.5 lb per ton of ore or $0.75 to $1.00 per ton. This will pay for a sizeable tank farm and two or three classifiers in a short time. After the practical limit of desliming, a dollar spent on starch or some other agent to block the remaining clay will save many dollars in amine. Thus, by some maneuvering, amine flotation reagent is made useful.

At the average potash plant, the ore is pulped in a brine saturated with both chlorides at about room temperature. After desliming, the clay blocking agent is fed into the pulp and then the amine, in that important order. After a very brief conditioning period, flotation of the sylvite is quite rapid.

It is generally becoming accepted that the mechanism of attachment of amine to sylvite in preference to halite is simply one of substitution of amine ion for a potassium ion in the surface of the crystal lattice. The brine is always either slightly supersaturated or undersaturated at the surface of the KCl particle, and thus K and Cl ions are always coming and going at the surface. If an amine ion happens by it will *plug* into a potassium hole as well as K ion, because its ionic radius is slightly smaller and there is ample room. Thenceforth, since it is a heavy weight, it moves away more slowly. Net movement of amine ions is, thus, toward the crystal, which then becomes selectively coated. Of course the same state of flux is occurring at the sodium chloride surface but the amine does not plug into a hole left by a wandering sodium ion because there is too little room. The radius of a sodium ion is about 30 pct smaller than that of the amine ion. This unique idea has been more or less secured by laboratory flotation of KBr from NaBr and RbCl from NaCl with amine. Rubidium ion, of course, is still bigger than potassium ion. After flotation, both tailings and concentrate are filtered.

The tailings filter cake is again pulped and pumped to the tailings pond. Filtrate, saturated with potash, is recycled to the plant, via a clarification step. The brine which accompanied the slime at the head of the circuit is also clarified and reused.

The tightness of the system, with regard to potash loss in brine, is a matter of economics. The low unit value of potassium chloride, as compared to some other minerals treated by hydrometallurgy, puts a fairly low limit on the amount of money which can be spent on closing inevitable potash exits.

The cake from the flotation concentrate filters is dried—generally in gas-fired cocurrent kiln dryers—and stored in buildings which hold from 50,000 to over 100,000 tons. The seasonal use of fertilizer demands large surge capacity for year-round operation of mine and mill.

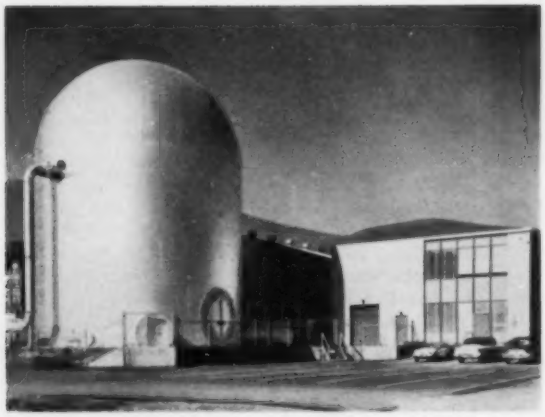
Potash Consumption: The industry's heaviest shipping season is in spring and starts early or late depending on the weather in the wet farming communities.

Most of the soil in the drier western states supposedly contains more potash than that in the wet states of the midwest and east, but agronomists generally advocate the use of balanced fertilizers. That is, if one of the three basic plant food elements, potassium, nitrogen, or phosphorus is used, some of the other two should be used. Nitrogen and phosphorus enter into the structure of the plant. Potassium is necessary for the proper use of the other two but does not enter into the anhydrous parts. Its action might be considered catalytic.

Consumption of potash has increased at a steady pace through the years, with only a minimum of cycling. When the cycling has occurred it has trailed general business activity by about one year. This again is because of the seasonal nature of fertilizer sales. The farmer never knows the outcome of the growing year until fall and a few months of general prosperity seems to precede a good farm season. Then the fertilizer is needed only in the following spring, about a year after the chain of events started.

This slow response is offset by another relationship between potash and society. A potash sales increase is more tightly tied to a population increase than in the case of most mineral commodities. This makes potash a reasonably secure business, but prone to high competition when supply suddenly increases. This is the present situation. It is probably healthy for the country as a whole and in a left-handed way for the industry. It is the age-old business of the moderate challenge, the overcoming of which, according to historian Arnold Toynbee, has caused civilization to grow.

The present appears to be the ripe time for the potash industry to take more of the bold steps in research and development which have been typical of its domestic history. The increase in reserves during the past six or eight years, in the Carlsbad area and in Canada, have put this hemisphere in an enviable position with regard to this most vital plant food.



CURRENT PROSPECTS FOR COMPETITIVE NUCLEAR POWER

by KARL COHEN

The question of attainment of competitive nuclear electric power is of interest to uranium producers because the rate of attainment of this goal determines the date when there will be a solid, non-political, domestic uranium market. It is a *burning* question to those of us in the civilian nuclear power business, because our entire business future hinges on how well, and how soon, we can make electricity from nuclear reactions at prices comparable to electricity from coal.

For an idea of the magnitudes involved, consider that the first fuel load of the Dresden (Illinois) nuclear power station, plus spares, will be about 90 tons of 1.5 pct UO_2. This requires about two-and-a-half times as much natural uranium oxide feed to the diffusion plant, or 225 tons. This, in turn, represents about a month's production from the nearby Uranium Reduction Co. mill. Note also that the 180,000 kw electric output of the Dresden station will be about 0.1 pct of the national electric generating capacity in 1960.

You have doubtless read newspaper accounts of the ambitious programs for the development of nuclear power in the United Kingdom and on the Continent, and may perhaps have wondered why in this country we seem to lag behind in the expansion of our nuclear power industry. The answer is threefold. In this country we are blessed with ample supplies of coal, oil, and gas. Consequently the bulk of the thermal power in the U. S. is generated from fuel costing less than 30¢ per million Btu. And we expect this situation to persist for the next 20 years. In European nations, the supplies of fossil fuel are running short, and costs for the next increments of fuel, either from uneconomic mining operations or shipped from overseas, run about 50¢ per million Btu and up. And on top of this price there is an unknown cost in national independence. Secondly, our electric power generating industry is ahead of the rest of the world in the production of electric energy from large, thermodynamically-efficient machines. Thus the technological competition is severe. Finally, electric generation is a private enterprise, which means that we do not subsidize electric power capital equipment by preferentially low capital charges. While current designs of nuclear power plants are economic—or nearly so— in Europe, they still have a long way to go to compete with our domestic fossil-fired plants.

The present economic situation is roughly as follows: Plant costs for the first generation of nuclear power stations are approximately double the cost of a corresponding fossil-fired power plant. The fuel costs range from 3.5 to 5 mills per kwh while fossil fuel costs range from 1.0 to 3.5 mills per kwh. The costs of plant operation and maintenance are basically unknown, but are projected to be higher for initial operations of nuclear power stations. The over-all cost of power from first generation nuclear power stations is in the range of 10 to 15 mills per kwh, which is about twice as high as we would like. We want to operate at 7 mills per kwh, or less.

There are many good reasons why costs are high at this time. Some reasons are common to any new industry, where new products are turned out in small volume by many producers. Manufacturing volume is low, engineering costs and development costs are high, and, characteristically, obsolescence of products and processes is rapid. All of these factors contribute to the costs of the new manufactured products needed for the nuclear power industry. The high cost of equipment results in low volume,

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which results in high cost output. This is the classic new business syndrome which certainly will be solved in this case, as it has been in the past, by good business management. An example of the scope of business management is as follows: During the starting phases of any industry, producers tend to spread themselves over broad product lines as a hedge against uncertainty about business outcome. This results in more duplication of facilities than is strictly required to provide healthy competition, and of course, aggravates the problem of low volume.

Another reason for high costs is excessive engineering margins. An example of this is the design condition which was set, on the basis of the knowledge then available, on the percent of steam voids in the core of our experimental Vallecitos (California) boiling water reactor. It was believed that limiting the reactivity compensated by these voids to 1.6 pct was necessary to assure stable operation. On this basis the maximum thermal power output was 20,000 kw thermal. During subsequent analysis it was found that this quantity had little direct relation to the stability. The reactor has already been operated at 30,000 kw, and it now appears that factors other than stability are more significant in determining the limiting heat output. We are now quite confident that we can get 40,000 to 60,000 kw from the Vallecitos reactor in the same mode of operation which was supposed to give 20,000 kw.

We have good reason to suspect that engineering specifications on fuel element design may have similar factors of conservatism. Discovering these factors through plant operating experience and further analysis and experiment will increase the number of kilowatts from a given piece of equipment, and hence reduce costs per kw.

A third area for cost reduction lies in pushing aside technological frontiers. Almost all reactor types have possibilities for fundamental improvements, either in their power generating cycle or in the fuel cycle. For example, boiling water reactors are particularly well adapted to the addition of nuclear superheat. A combination nuclear boiler-superheater, by improving steam conditions at the turbine, has potential for further cost reductions.

The attack on high nuclear power costs would appear to be three-pronged:

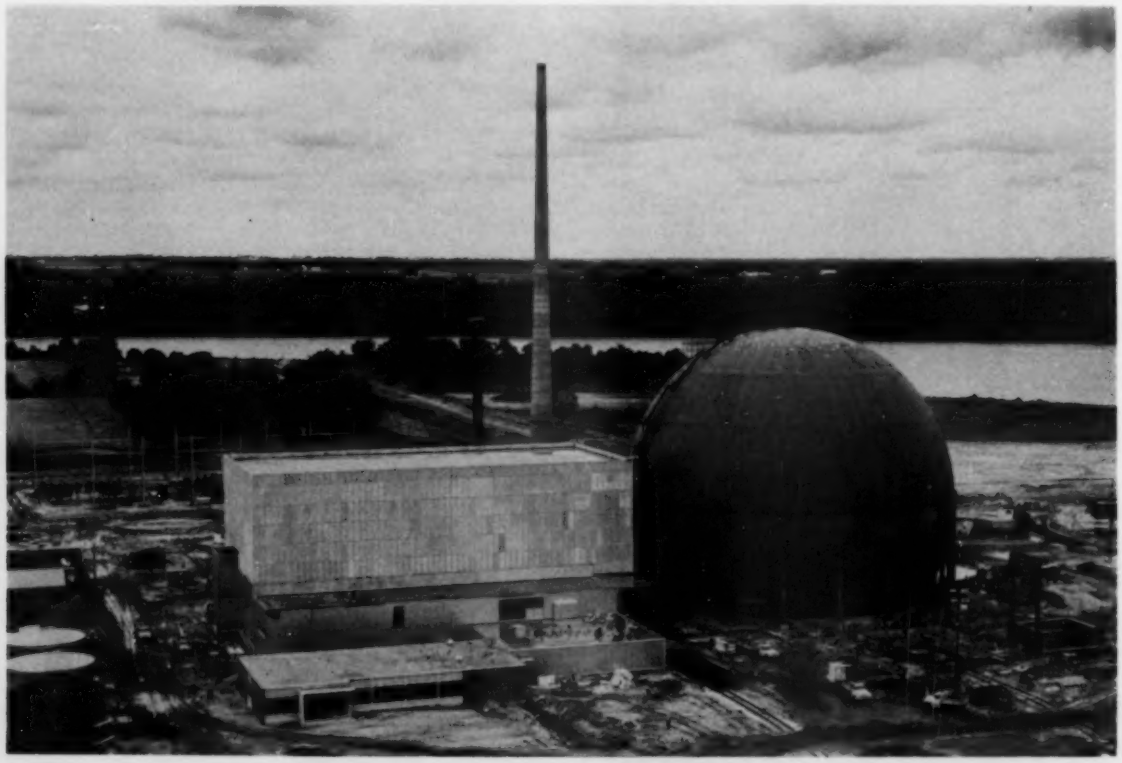
► To advance the technology to use more efficient steam conditions, cheaper and more reliable materials, and simplified design.

► To increase the specific power which can be extracted from a given size or weight of equipment.

► To reduce manufacturing costs by standardizing products and increasing manufacturing volume.

The first two objectives can only be achieved by experimentation, so we need a vigorous program of research and development. But increased manufacturing volume can only come about by building plants.

One of the reasons the British have had a degree of success with a basically unpromising reactor type, has been their concentration of the entire national effort on the one reactor. To reap the benefits of standardization and repetitive volume, we should concentrate our national program.



Dresden nuclear power station, southwest of Chicago

MINERALS FOR INSECTICIDE FORMULATIONS

A number of non-metallic minerals are valued by formulators as excellent carriers for modern insecticides. Western formulation and use is discussed.

by HENRY T. MULRYAN

Since World War II, U. S. chemical companies have loosed a flood of synthetic organic insecticides. These synthetics fall into two broad categories. DDT is the best known of the chlorinated hydrocarbons and Parathion is the most famous (or infamous) of the organic phosphate *nerve gas* type.

Insecticide poisons are not applied at full strength but as dilute sprays or dusts. This permits a broader and more efficient distribution of the active killer.

Usual practice is to reach field strength of 1 to 10 pct toxicant in two steps. The first step is to produce a dust base or wettable powder containing 25 to 75 pct active toxicant. Later, the concentrate is diluted with water or inert minerals for field use. Concentrating allows the formulator to make efficient use of storage space, reduces freight costs in the event the material is to be further diluted at another location, and permits flexibility in mixing various toxicants in finished dusts.

The new insecticides are waxy solids or oily liquids which are ground with or sprayed on highly absorptive minerals to produce a free flowing concentrate. Fuller's earths, montmorillonite and attapulgite, produced in Florida, Georgia, and California are by far the most important carriers. These minerals are highly sorptive, of low abrasion, and moderately priced at 1½ to 2¢ per lb, delivered. Fuller's earths are kiln dried and ground in roller mills to 90 to 95 pct −325 mesh for carrier use. Producers must maintain rigorous quality control or a customer may find a soggy, sticky mess in his mill instead of a dry, free-flowing powder. The fullers' earths are quite easy to wet and disperse in water and make excellent carriers for wettable powders which are diluted with water and applied as sprays. Most fuller's earths have the disadvantage of contributing to the decomposition on storage of several important poisons. Toxicant producers have devised means for eliminating their chemical reactivity in connection with the sensitive chlorinated hydrocarbons such as dieldrin and heptachlor but use with certain organic phosphates such as Methyl Parathion and Malathion remains a serious problem.

Formulators have recently experimented with an unusual combination of high-purity, ultrafine talc and very highly sorptive synthetic calcium silicate or colloidal silica to make 20 to 25 pct Methyl

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Parathion concentrates. The silica boosts total sorption to provide a free flowing powder.

The strong emphasis on high cost, high efficiency organic phosphates of doubtful stability portends a wider use of exotic carrier systems for their protection.

Extremely high concentrates such as wettable 75-pct DDT require greater sorptive power than fuller's earth can provide. Calcium silicate, made from diatomite and hydrated lime, and colloidal silica are therefore used for this purpose. The former is produced in California and the latter is shipped from the east. High concentrates are almost always made for shipment over long distances, especially for export; they constitute important volume in the San Francisco and Los Angeles areas. The high concentrates require special milling equipment for quality control and the cost of the carriers is high, ranging from 7 to 10¢ per lb.

Field dust diluents are low-priced minerals whose only function is to assure good dispersion and deposition of the active toxicant. They are usually ground to about 95 pct—325 mesh. Proper bulk density, good flow characteristics, inertness toward the insecticide, and low abrasion are requisites for a good diluent.

Pyrophyllites and soapstones of local production and selling for a cent or less per pound have the lion's share of the western market. Formulators often add minor percentages of fuller's earth or diatomite as bulking and anti-caking agents and to improve flow. Flow is an important and complex subject but can be briefly summed up in the point that a usable dust must flow and a bulky dust will usually flow better than a heavy one. The importance of flow can be appreciated by imagining the plight of a duster pilot with a planeload of dust which sticks in a hopper he cannot reach without landing. Such bulky minerals as fuller's earth and diatomite cause another problem, however. Dust formulated with them alone tends to hang in the air and drift and would probably never reach the intended field on a hot day. The majority of field dusts, therefore, represent a compromise of desirable characteristics derived from a blend of minerals. The method of application, weather conditions, and the crops to be treated all determine the nature of the compromise.

One characteristic upon which there is no possible compromise is that of compatibility with the toxicant. Free moisture and ion exchange capacity are the main factors in measuring compatibility of a carrier or diluent. As in the case of fuller's earth, many common dust diluents attack certain insecticides. A nonexistent insecticide is not going to kill anything, no matter how beautifully the dust may be deposited.

Western minerals producers have responded to this problem with an array of non-reactive diluents. The most important of these are talcs and specially treated gypsum, volcanic ash, and calcium carbonates (calcined to remove all free moisture and most of the combined water). These increase the cost of the diluent systems but this is an insurance premium paid for the protection of toxicants valued in terms of dollars, not cents, per pound.

Most toxicant producers feel the fuller's earths and other clay minerals have a catalytic effect on ring and chain chlorinated hydrocarbon breakdown. This may be due to exchangeable cations on the carrier surface. In some materials these consist, in part, of H^+ ions which actually may enter into a reaction with the Cl^- in the compound. DDT decomposition, for example, is characterized by liberation of HCl. The chemical *deactivators* recommended by some toxicant producers for their chlorinated hydrocarbon insecticides are an application of the principle of satisfying this exchange capacity prior to the formulation of the concentrate. Talc and the stearate-coated calcium carbonates are very low in ion exchange capacity and free moisture and therefore are among the most stable diluents.

Sulfur is a pesticide and not a diluent. It is of great commercial importance and is of special value for the control of citrus and cotton pests. Formulators usually combine sulfur with organic insecticides and diluents for wide spectrum killing power.

Production and use of kaolins for insecticides in the west is of minor importance. Kaolin and swelling bentonite are of considerable commercial significance in other parts of the country, however.

Granular insecticides have recently gained national prominence and are widely used in the Pacific Northwest. They are made by spraying the poison on fuller's earth or vermiculite granules of 20 to 40 or 30 to 60 mesh. Granules are most effective against soil insects and mosquito larvae because of their ability to penetrate dense foliage. They are also safer to apply than sprays or dusts because they are not subject to drift. California and Arizona have been slow to utilize granular formulations but certain advantages of granules are obvious and they may be of major importance in the near future.

With few exceptions, freight rates prevent marketing of diluents beyond a 500-mile radius of the producing point. There is no chance to balance out the highly seasonal pattern of use by shipping to areas with widely varying climates.

Two recent developments have complicated this problem. The most important of these is the more general acceptance of emulsifiable concentrates for sprays on early-season cotton. This has not only reduced the volume of diluents for cotton dusts but squeezed the peak season into three months—July, August and September. Insects hiding in tall cotton are less easily reached by sprays than dusts during this season. The second change is the production of adequate diluents in Mexico—formerly a large market for U. S. materials from February through September.

The foregoing presents a gloomy picture but only in relation to the recent past. Total usage of insecticides is expanding so that enormous quantities of dust diluents move to formulators each year despite the increasing importance of liquid formulations and Mexican competition.

Competitive effect on carriers has been much less marked because carriers enter into wettable-powder as well as dust-base production. Emulsions based on petroleum solvents sometimes damage tender crops; wettable powders seldom do and will continue to hold a sizeable share of the spray materials market. Winter and spring exports of concentrates also modify seasonal variations of carrier sales.

The new toxicants require an exact knowledge of the diluent and its effects on the active ingredient and the insect. The interest in specialized diluents and carriers for specialized uses is the result and should work to the benefit of all, especially those primarily concerned—the farmer who grows the crops and the consumer who uses them.

ADVANCES IN MAGNETIC SEPARATION OF ORES

Magnetic separation of iron ores is one of the fastest-growing segments of the minerals beneficiation industry. The tonnage of taconite ores processed annually by magnetic separation will, in a few years, reach 100 million.

by L. A. ROE

Magnetic separation occupies an attractive position in the field of ore beneficiation. It is a simple yet effective method, used for some 150 years and steadily growing more important. This type of beneficiation orginated in 1792, when William Fullarton was issued a British patent covering the separation of iron ore by magnetic attraction.

What is magnetism, and why are some materials capable of being magnetized and others not? The study involves many unknowns, and even a partial answer to these questions would be a dissertation in solid state physics and perhaps other fields of science. But the last two decades have revealed basic facts as to why certain materials are magnetic and what happens to them when they are magnetized.

Some of the newer studies in solid state physics have developed a theory that can be applied to studies of magnetism. It is claimed that magnetism stems fundamentally from the spin of electrons in atoms that tend to go in pairs, spinning in opposite directions. The atom as a whole can act as a magnet only when there is an imbalance of electronic spin. Whenever an atom has an odd number of electrons, therefore, this imbalance exists. This neutralizing effect explains why a piece of material that contains atomic magnets is not necessarily magnetic. The physicists tell us that iron is composed of many small magnetized regions called *domains*, which consist individually of millions of atoms. The piece of iron becomes magnetized when an external force lines up these *domains* in the same direction. Fundamental data developed by physicists working in fields far removed from minerals beneficiation are now available for developing better magnetic separators for ore processing.

L. A. ROE, Member AIME, is Director of Central Engineering, International Minerals & Chemical Corp., Skokie, Ill. TP 4781B. Manuscript, May 28, 1958.

More Data Needed on Magnetic Properties of Minerals: There is less information on magnetic properties of minerals than there is for certain aspects of magnetic separator design. When the data on magnetic properties is available, it is often directed toward the study of powders for tape recorders and other highly scientific endeavors that are of little use to the beneficiation engineer. W. R. Crane's table of tractive forces, published in 1902, is still a guide in the study of magnetic minerals. Bits of other information regarding electrostatic conductivity, dielectric constant values, and permeability of various minerals have also appeared but are of small practical value in magnetic separation of ore.

It is extremely important to obtain pure mineral specimens for making investigations and to record results that may be of use in studies of magnetic processes. Reference to the large volume of data developed by those concerned with analysis and design of permanent magnets soon reveals that these people have extensively evaluated the effect of various *impurities* on magnetic properties. Much of the science of the ferrite industry is based upon spinel-type structures which are varied by substitution of selected elements or even subtraction of elements, leaving vacant sites in the space lattice.

Magnetic separators are used to beneficiate a wide variety of industrial minerals. In this application the relatively large volumes of nonmagnetics are usually the commercial products. The amount of mag-

The Transactions papers appearing in MINING ENGINEERING *during 1958 will subsequently appear in AIME Transactions Volume 211, and may be permanently referenced to that volume.*

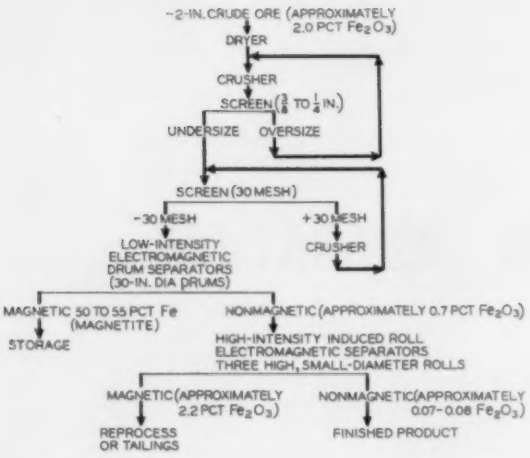


Fig. 1—Dry magnetic processing of nepheline syenite.

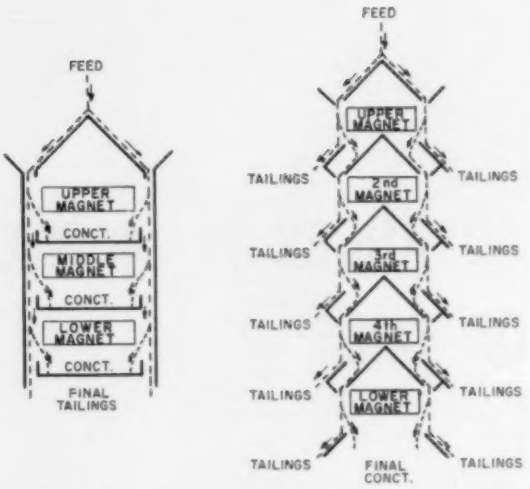


Fig. 2—No. 1 (left) and No. 3 Edison separators, 1890.

netic material removed is quite small, and dry separation is the general rule.

Magnetic separation is also important in processing phosphate, titanium, chrome, manganese, tungsten, molybdenum, nickel, niobium, and tantalum ores.

Pioneer Work on Dry Separation: It is interesting to note that much of the pioneer work in magnetic processing of ores was done on dry material. In spite of the disadvantages of dusty, uncomfortable plants, the dry method has produced acceptable concentrates in most cases.

No definite date can be given for the change in emphasis from dry to wet processing of iron ore, but the wet processing method is treating by far the largest tonnage at the present time. In the past two or three years many advances in the science of magnetic separation of iron ore have been in the field of dry processing, where a major revolution in iron ore beneficiation may be taking place. But now consider an area of magnetic separation where dry methods have never lost their attractiveness.

Table I. Iron Analysis of Crude and Beneficiated Minerals Used in the Ceramic Industry

Mineral	Crude Ore, Fe_2O_3, Pct	Beneficiated Product, Fe_2O_3, Pct
Aplite	0.60 to 1.30	0.30
Glass sand	0.15 to 0.20	0.01 to 0.03
Feldspar	0.15	0.05 to 0.07
Nepheline syenite	1.7 to 2.1	0.07 to 0.08

Table II. Typical Results Obtained with Edison Dry Magnetic Separator

Feed	20 pct Fe (0.7 to 0.8 pct P)
No. 1 machine concentrate	40 pct Fe (tails 0.8 pct Fe)
No. 2 machine concentrate	60.0 pct Fe
No. 3 machine concentrate	68.0 pct Fe
Total concentrate	68.0 pct Fe, 2 to 3 pct SiO_2
Total tail	1.12 pct Fe
Finished Briquettes	
Fe, 67 to 68 pct	Mn, 0.05 to 0.10 pct
SiO_2, 2 to 3 pct	P, 0.028 to 0.33 pct
Al_2O_3, 0.4 to 0.8 pct	Traces of CaO, Mgo, and S

Importance to Industrial Minerals Production: Several industrial minerals used in manufacturing ceramics have long been processed by dry magnetic separation—kyanite, quartz, aplite, feldspar, and nepheline syenite, which is currently processed in considerable quantities in Canada and Russia.

Extensive deposits of nepheline syenite occur in Russia, Scandinavia, India, the U. S., and Canada. The Canadian deposit that is commercially exploited, near Nephton, Ont., is unique in its uniform quality and low percentage of iron-bearing minerals. This orebody, known as Blue Mountain, is more than five miles long and up to a mile wide. Located by Norman Davis in 1912, it has long been known to be one of the world's most extensive deposits of this material. Before the Blue Mountain ore was considered for use in the ceramic industry, it was studied as a possible source of aluminum and also as a source of potash.

Instead of bauxite, according to a recent Russian announcement, the Volkhov Aluminum Works near Leningrad is successfully using nepheline, which comes from the extensive apatite deposits of the Kola Peninsula. Besides aluminum, the Russians are recovering gallium, sodium and potash salts, and constituents of Portland cement.

With the formation of Canadian Nepheline Syenite Ltd. in 1935, the Canadian deposit was seriously investigated as a feldspar substitute for the ceramic industry.* Feldspar that has a relatively high alkali and alumina content has also been preferred by the glassmakers to the less readily available potash feldspar. The search for a substitute that might be even better in some cases than feldspar led to investigation of the nepheline syenite deposits in Canada. The first test sample, weighing 30 tons, was concentrated by high-intensity magnetic separation and distributed to ceramic plants in Canada and the U. S. for test purposes. It soon appeared that nepheline syenite would be a useful substitute for feldspar, and the market has grown steadily until now it is considered one of the major minerals used in the ceramic industry. Among the companies now oper-

* Feldspar has been used in China as a ceramic material since 621 A. D.

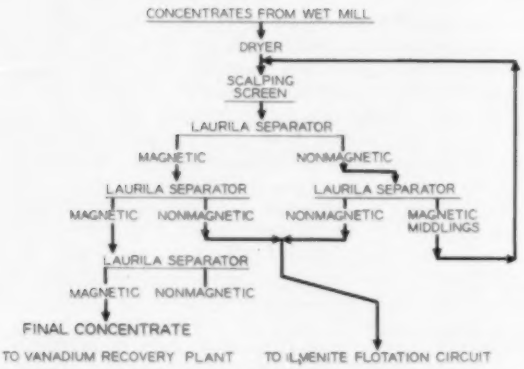


Fig. 3 (above)—Otanmaki dry magnetic separation plant.

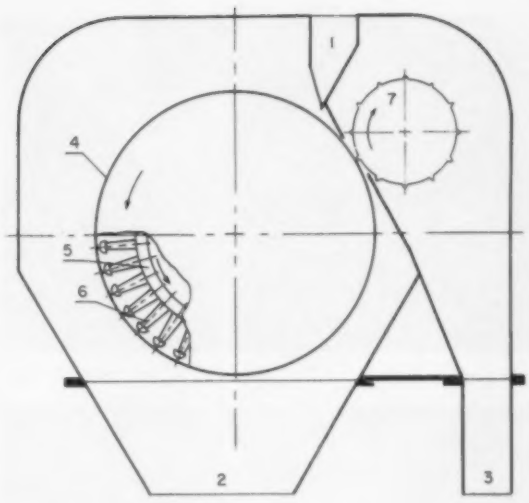


Fig. 4 (right)—Laurila separator: 1) feed introduction, 2) tailing discharge, 3) concentrate discharge, 4) drum, 5) magnet carrying wheel, 6) permanent magnet, 7) induction roller. (Also see Figs. 5A and B, p. 1264.)

ating in Canada are American Nepheline Co., successor to Canadian Nepheline Syenite Ltd., and International Minerals & Chemical Corp. (Canada) Ltd. For purposes of this article the overall flowsheets of these plants will not be discussed, but the magnetic separation features will be described.

Dry Magnetic Separation of Nepheline Syenite: The first equipment used in magnetic separation of nepheline syenite is a low-intensity, large-diameter drum separator to remove highly magnetic minerals —primarily magnetite or mixtures of magnetite and other elements. The magnetics removed by this electromagnetic separator are placed in a storage pile or sold as byproduct magnetite. The magnetite concentrate analyzes 50 to 55 pct Fe. The nonmagnetic product from the first separator is stored in surge bins, from which it is drawn for distribution to high-intensity induced-roll magnetic separators, which remove feebly magnetic minerals.

Generally about 25 pct of the ore fed to a nepheline syenite plant is lost as waste during crushing, drying, grinding, and reduction of iron content, which is usually lowered from 2.0 to 0.08 pct. Table I compares iron analyses of several crude and beneficiated ceramic raw materials that undergo dry magnetic separation.

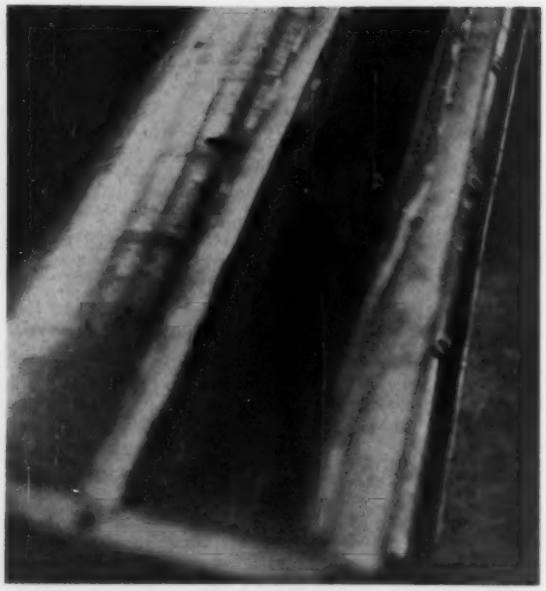
Dry Magnetic Separation of Iron Ore: There are many inherent advantages in processes that utilize dry magnetic separation to beneficiate iron ore. Wet concentration of magnetite ore, in comparison, requires 500 to 1000 gal of water per ton of concentrate produced. This means extensive use of water resources, as well as disposal systems and sometimes complicated water reclamation systems. Some of the new low grade iron ore discoveries in Canada are in areas where the climate encourages use of dry processing methods.

Production of superconcentrates also favors these methods for iron ores. As Thomas Edison demonstrated more than 50 years ago, it is not difficult to produce large tonnages of concentrates containing 68 pct Fe and only 2 to 3 pct SiO_2 when dry magnetic separation procedures are used. One of Edison's pilot plants consistently produced concentrates of more than 71 pct Fe.

Edison devoted eight years, at a cost of more than $2 million, to inventing a magnetic process and constructing a plant for concentrating low grade iron ore into desirable furnace feed. In the 1890's, recognizing the iron industry's dependence on the somewhat limited ore supplies in the East, Edison developed a method of separating iron minerals from the iron-bearing sand he had observed along the shore of Long Island. After preliminary small-scale tests with these sands, he constructed a large plant near Lake Hopatcong, N. J., to beneficiate a low grade magnetite ore and founded the town of Edison, N. J., to provide homes for the workers. Among the plant's many innovations were new crushers, belt conveyors, dryers, and briquetting machines, as well as inventions in magnetic separation.

Edison's developments in magnetic separation, which have not been widely publicized, were characterized by simple construction. The separators he finally installed in his commercial plant consisted of several electromagnets arranged one above the other, utilizing a free-fall principle to separate gangue from magnetite. The commercial plant in New Jersey used four separators, which he designated Nos. 1 through 4. It is significant, with reference to the data for this plant listed in Table II, that ore containing only 12 to 20 pct Fe was upgraded to concentrate containing 68 pct Fe. Present-day proponents of the smelting advantages of extremely high grade iron ore concentrates will be interested in the outcome of tests made with Edison high grade iron ore concentrate at Catasauqua, Pa. Results of a five-day test were spectacular. On the regular ore charge this furnace produced 100 to 110 tons of pig iron per day. When briquetted concentrates from Edison's plant were used, furnace output rose to more than 138 tpd. Altogether, 477 magnetic separators were installed in the New Jersey plant.

After Edison's New Jersey plant failed, U. S. interest in large-scale magnetic separation of iron ore decreased. Edison's failure was caused primarily by the sudden drop in the iron ore market following discovery of the great Mesabi Range. The New Jersey deposit, moreover, was inadequately prospected and of lower quality than anticipated.



Figs 5A and 5B—Laurila separator in the Otanmaki Co. shop. Lower view is close-up of the drum.

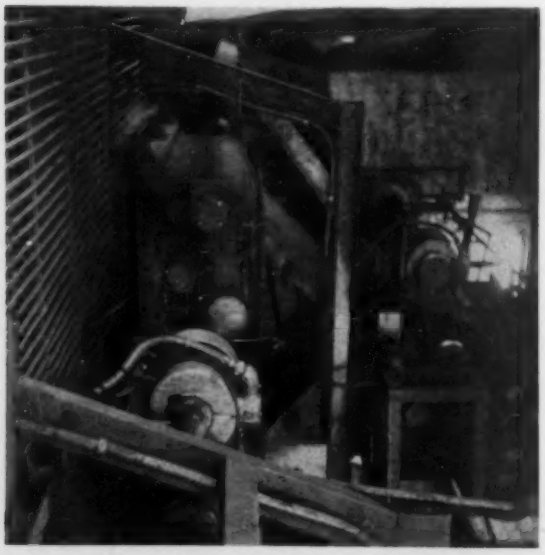


Fig. 6—The Laurila separators in commercial operation.

Now there is renewed interest in dry magnetic separation of iron ores. Some of the more recent studies of dry separation methods have been undertaken in: 1) the Ontario Research Foundation; 2) the Finland Institute of Technology, Helsinki, and the Otanmaki Co; 3) the ore dressing laboratory of the Royal Institute of Technology in Stockholm, Sweden; 4) Carpco Research & Engineering Div., Carpco Mfg. Co., Florida; and 5) various German laboratories and the Salzgitter Co.

Otanmaki Commercial Plant Operations: The Otanmaki Co. in Finland is processing, in considerable tonnages, ilmenite-magnetite-pyrite ore similar to that mined at Tahawus, N. Y. As this article is concerned chiefly with new developments in dry magnetic separation, no description will be given of the wet mill, but it should be mentioned that a highly efficient wet magnetic separation circuit is used to remove a very large percentage of magnetite from the ilmenite. This is important, since any magnetite going to the ilmenite flotation circuit is lost to the ilmenite and downgrades the ilmenite product.

Fig. 3 is a flowsheet of the dry magnetic separation plant at Otanmaki. Wet filtered magnetic concentrate is picked up by a magnetic pulley from a conveyor belt and fed into a drum dryer. The dried concentrate is fed by elevator to the dry magnetic separation section.* Here a scalping screen removes tramp oversize prior to the dry separation step. The dried concentrate is then fed to Laurila separators, where centrifugal force separates the nonmagnetic or weakly magnetic particles from the magnetic. Invented by Erkki Laurila of the Finland Institute of Technology, this drum-type separator incorporates permanent magnets made of Alnico V or similar material. The machine is undergoing further development, both at the Institute and at Otanmaki. It is now manufactured by Maschinen-und Stahlbau, Krupp Rheinhausen, Germany.

* It should be realized that the ilmenite-magnetite operation at Otanmaki involves a separation that could not be made economically by wet magnetic methods.

At Otanmaki the rougher concentrate is cleaned twice by dry separators. The rougher tailing is sent over a cleaner separator operating at lower speed, and the final tailing containing ilmenite is sent back to the ilmenite flotation section.

Operating conditions in the dry separator section are difficult. Separator design includes an oil mist lubrication system to spray the bearings, since the dry magnetite concentrate is at 120° to 140°C. Thermal expansion of the separator shells has also caused trouble.

During the period covered by the Otanmaki commercial plant results listed in Table III, the magnet wheel was stationary and the drum speed was 230 rpm on the rougher and 180 rpm on the scavenger separator. These results show that 11 pct of the

Table III. Otanmaki Plant Results with Dry Magnetic Separation

	Fe, Pct	TiO_2, Pct	Fe_2O_3, Pct	Distribution, Wt, Pct
Feed	65.5	5.7	86.9	100.0
Magnetite concentration	68.6	2.15	95.6	89.0
Middlings	60.5	8.3	75.8	10 to 15
Tailing	36.2	36.9	7.5	11.0

Magnet wheels stationary. Drum speeds 230 rpm, except scavenger separator at 180 rpm.

Table IV. Types of Magnetic Separators Used in Swedish Iron Ore Mills

Mill	Separator, Type	Size, In. Diam x Length	Drum, Rpm	Power, Kw
Balsjo, Sweden	Lowenhielm in (rougher) (2) series		39	
			52	2.5
	Lowenhielm in cleaners (3) series		52	
			68	
			75	
Carl Shaft mill, Striberg, Sweden	Lowenhielm	24x35	40	2.1
Hematite HMS plant	(8) magnetic circuit			
	(19) Lowenhielm	24x35	64	3.7
Stripa mill	Lowenhielm			1.45
	Rougher, two in parallel cleaner			1.46
Haksberg mill	(2) Vulcanus countercurrent cobber	37x34	35	3.7
	(2) MF2, Morgardshammer cobber	28x33	36	—
	(26) Lowenhielm	24x34	46 to 50	1.25
Persberg	(1) Jeffrey rubber covered counter-current drum	35x36		1.5 hp
	(25) Lowenhielm	24x34	44 to 60	1.4 hp
	(3) Thunes (three-drum) (perm magnets)	24x69		
Bodas mill	(9) Lowenhielm 3-mm thick rubber-covered drum	24x34	50	1.9 hp
Kallfallet	(9) Grondal	31x35	45	1.5 hp
Langnas	(20) Lowenhielm	24x34	54 to 62	2
Dannemora	(6) Morgardshammer GW617P (perm magnets) rubber-covered (three in series)	25x68	103	1
Bastkarn	Lowenhielm	24x34	75	2.5 ph
Kantorp	(5) Lowenhielm (2) Allians			
Grangesberg	Allians	50x22		
	Thunes (perm magnets)	24x69		
Blotberget	Thunes (perm magnets)	24x71		2
Tuolluvaara	(15) Drum (perm magnets)	24x67		
Malmberget	(70) Harden	32x32	30 to 32	
	(8) Thunes (perm magnets)	24x67	30 to 32	

Note: Number of separators installed noted in parentheses. Power in kilowatts unless otherwise specified.

original feed is removed as a tailing product. Examination of the middlings has shown that no reasonable amount of regrinding will liberate the minute veinlets of magnetite in this fraction.

Early work on the Otanmaki dry magnetic process indicated that fatty acid materials added during drying operations were beneficial in the dry separation of this ore. Materials such as oleic acid, fuel oil, sulfuric acid, tall oil, and caustic soda were added prior to the drying stage. The fatty acid reagents formed a coating on individual particles which apparently helped disperse the mineral particles. Despite these initial successes, however, the commercial plant has stopped using fatty acids and is obtaining satisfactory results without adding chemicals to the magnetite.

Salzgitter Separator: In Germany the 30-in. dry magnetic separator* manufactured by Erzbergau Salzgitter A. G. is now commercially treating 5 to 6 tph of hematite and goethite ores at about 1 kw-hr per ton of feed. This unit uses a maximum field intensity of 23,000 gausses, which can be compared to a maximum of 14,000 gausses in a laboratory Davis tube separator. The magnetic circuit is energized by two air-cooled d-c coils. The four induced rolls have corrugated surfaces and the spacing between the pole pieces and the rolls is considered critical.

* Designed by A. Goltz of the Salzgitter Co.

The Ontario Research Foundation has developed several new dry magnetic separators designed for ore beneficiation, each for a specific particle size range, though as yet there are no commercial installations. For several years this institution has used dry concentration methods to produce the superconcentrates needed for sponge iron tests. Recent investigations have developed a complete dry magnetic separation flowsheet, which has been used upgrade on ore from 25 pct Fe to more than 63 pct Fe.

Wet Magnetic Separation of Iron Ore in Sweden: In Europe, especially Scandinavia, the drum-type wet magnetic separator is very popular, both the electromagnetic and permanent magnet types. A major difference as compared to U. S. separators is that the drum is near the surface of the pulp. In other words, the pulp level is very low, as it was in the early Grondal separator, used successfully since the turn of the century.

In general, it can be said that foreign plants favor large numbers of lower-capacity machines. At the same time, they often produce a higher grade concentrate, which is in much demand for sponge iron and powdered iron production.

It is highly important to the iron ore industry that more efficient magnetic separators be developed. A speaker at the American Mining Congress in September 1957 stated that the steel industry is shifting emphasis from cost of ore to cost of steel in the ladle. Further, it was claimed that steel costs can be reduced 26¢ per ton for each percentage point reduction in silica content of concentrates such as taconite pellets.

Recent success in new designs of dry magnetic separation machines points up the impending production of higher-quality iron ore. This trend will be accelerated by the growing sponge-iron industry's demand for superconcentrates. And in the industrial minerals field more efficient removal of iron-bearing minerals can be expected as developments encouraged by the iron ore industry are adopted by industrial minerals operations.

Discussion of this article sent (2 copies) to AIME before Jan. 31, 1959, will be published in MINING ENGINEERING.

LUCKY FRIDAY MINE: HISTORY, GEOLOGY, AND DEVELOPMENT

By WILLIAM T. FOLWELL

The Lucky Friday mine east of Mullan, Idaho, is an outstanding example of a property in the Coeur d'Alene district where a small and insignificant-appearing silver-lead-zinc vein at the surface has changed at depth into a large vein of great importance. The Lucky Friday vein has little if any surface expression and above the 1200 level the ore shoots are small and discontinuous. Between the 1200 level and 2450 level, the lowest developed level, the main ore shoot has shown remarkable improvement on each succeeding lower level, and today the mine is one of the major lead-silver producers in the Coeur d'Alene district.

History: The Lucky Friday property is on the north side of the South Fork of the Coeur d'Alene River in sections 25, 26 and 35, T. 48 N., R. 5 E., Hunter mining district, Shoshone County, Idaho. This is about one mile east of the town of Mullan, which serves the eastern portion of the Coeur d'Alene district. The southern part of the property is crossed by a branch line of the Northern Pacific Ry. and by U. S. Highway 10. This highway is the principal road crossing the panhandle of Idaho and connects the district with Spokane, Wash., on the west and Missoula, Mont., on the east. The main portal and surface plant of the Lucky Friday mine is at an elevation of 3365 ft, only a short distance above the valley floor and a few hundred feet from U. S. Highway 10, so the mine is readily accessible for year-round operation.

The property is comprised of six claims, known as the Lucky Friday group, owned outright by the Lucky Friday Silver-Lead Mines Co. There are four patented claims, Good Friday, Lucky Friday, Northern Light, and Lucky Friday Fraction No. 2 (Mineral Survey No. 3028), and two unpatented claims, Hunter and Creek.

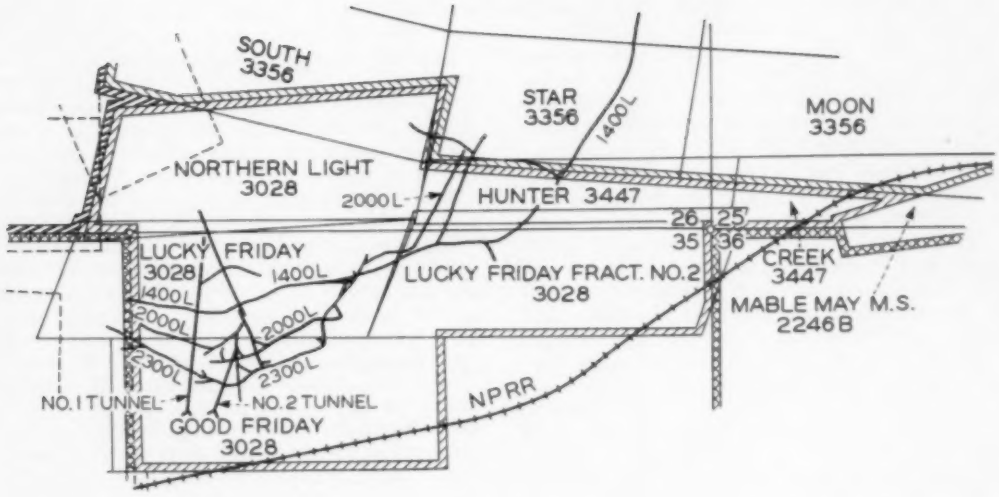
In addition, Lucky Friday owns an undivided one-half interest in the Hunter Creek property, which adjoins the Lucky Friday group on the north; a 90 pct interest in the mineral rights in the Jutila Ranch (160A), which adjoins the Lucky Friday group on the east; and a 60 pct interest in the Lucky Friday Extension claim group, which adjoins the Lucky Friday group on the west. The company also has a long-term mining lease on the Hunter Ranch, which adjoins the Lucky Friday group on the west.

The claims of the Lucky Friday group were located between 1899 and 1906. The Lucky Friday Mines Co. was organized in 1906 and did considerable exploration work by surface trenching and shallow underground workings, only to see the property sold by the Shoshone county sheriff to satisfy labor claims totaling $2000 in 1912. Another firm, Lucky Friday Mining Co., bought the claims in 1914 and spent 12 years driving what is now known as the tunnel level crosscut. This tunnel intersected a vein previously exposed in a higher tunnel, but it was only a few inches wide. The vein was followed a short distance westerly but was so unpromising that the work was discontinued in favor of extending the main crosscut tunnel several hundred feet north. No ore was found and all work was discontinued. The property was held in such low esteem by the firm that it let taxes amounting to less than $15 a year go delinquent for nine years.

Then the property lay idle for two more years until in 1938 John Sekulic, a Mullan service station operator, took a lease, with a $15,000 purchase option, on the advice of an old miner who had worked in the mine. Sekulic re-opened the tunnel level crosscut and explored the vein with an easterly drift for about 200 ft. The vein was too narrow to be of commercial value but was believed interesting enough to warrant further exploration at depth. Lacking funds to explore the vein at depth, Sekulic tried to get the district's larger operating companies to take over his lease and option. They were not interested because of the lean tunnel level showing and the fact that the property lay between the White Ledge fault on the north and Osburn fault on the south, an area which geologists always considered unworthy of exploration.

Sekulic then organized the present company and assigned his lease and option to it for stock. This was in 1939. Enough stock was sold locally to finance sinking of a shaft 100 ft from the tunnel level east drift. The vein at this additional depth still was not commercial but showed some improvement. Treasury stock was offered at 5 to 10¢ a share

W. T. FOLWELL, Member AIME, is Mining Engineer and Geologist, Lucky Friday Silver-Lead Mines Co., Wallace, Idaho. TP 4780A. Manuscript, June 3, 1958. AIME Pacific Northwest Regional Meeting, April 1958.



to finance deeper work, but few buyers were found.

Finally, the late Judge Albert H. Featherstone of Wallace, then president and manager of Golconda Lead Mines, and his son, John A. Featherstone, financed deeper development. Part of the cost was raised through a bank loan; directors also loaned the company money. The vein did not yield commercial ore until a depth of 300 ft was reached, and there the vein was narrow and the ore shoot only 25 ft long. Since the start of the present company operations the net smelter returns have been nearly $8 million and the company has paid $1.5 million in dividends.

Development: The mine is developed through two vertical internal shafts, both collared on the tunnel level at an elevation of about 3365 ft. The original shaft was sunk to the 2000 level and was used to explore the vein at 200-ft intervals to that depth. The new three-compartment shaft, 325 ft south of the original one, extends to a depth of 3142 ft and is used as the main hoisting shaft. This new shaft was raised from the 2000 level to the tunnel level and sunk from the 2000 level to the 3050 level. Below the 2000 level the vein is developed by crosscutting and drifting from the new shaft at 150-ft intervals. The crosscut distance from the shaft to the vein on the 2450 level is 200 ft and the distance to the vein on the 3050 level is expected to be about 475 ft. The vein has not been explored below the 2600 and 3050 levels. A large sump and primary pumping station has been installed on the 3050 level, so except for station enlargements and pockets, the major facilities for deeper exploration and development of the mine are completed.

Most of the mining is cut-and-fill. As a whole the ground stands well and very little timbering is required in the drifts until development raises have been driven and the stope sections are prepared for mining. Until recently two-cap, timbered raises with a combined slide and manway and joker compartments on each side have been used in most development work but now three-cap raises with separate slide and manway compartments or a modification of this type are being used on the new development work. The raises are driven approximately 100 ft apart and the intervening blocks of ground are mined cut-and-fill with little timbering. Waste fill, usually obtained from exploration headings, is transferred to the stopes through the raises.

The ore is milled on a custom basis at a 200-tpd flotation plant 5 miles away owned by Golconda Lead Mines.

Geology: The Coeur d'Alene district is principally underlain by metamorphosed sedimentary rocks of the Pre-Cambrian Belt Series. In the district, the Belt series, aggregating more than 20,000 ft in thickness, has been divided into six formations by the U. S. Geological Survey. These are, in ascending order, the Prichard, Burke, Revett, St. Regis, Wallace and Striped Peak formations.

Bedding: Most of the sedimentary rocks are of shallow water origin and have been regionally metamorphosed so that the prevailing rocks of the district are quartzites, argillites, slates, calcareous shales, and rocks of intermediate composition. Because of the common origin and similarity in composition few sharp transitions occur in the sequence and in many places the transition from one formation to another is poorly defined and the contact can only be approximated. In areas of extreme folding and faulting, and especially in structurally complex areas of intense bleaching and alteration the division between formation is even less certain.

Folding: The rocks of the district have been intimately folded into a complex system of anticlines and synclines. In many of the folds the beds are sharply contorted and crumpled, and some of the folds are overturned; thus throughout much of the district the strata are inclined at angles greater than 45° and in many places are vertical. The axes of the major folds of the district have a general east-west trend.

Faulting: In this district faulting is as pronounced and as complex as the folding. The most noteworthy fault is the Osburn, which crosses the district in a west-northwesterly direction and has been traced for many miles east and west of the district. The apparent vertical displacement along the Osburn fault is as much as 10,000 ft and the horizontal displacement is thought to be as much as 12 to 15 miles, with the south block moving west relative to the north block. North of the Osburn fault many of

the major faults trend northwesterly or northerly, while in the southerly part of the district the larger faults have trends more nearly parallel to the Osburn fault. Most of the east-west trending faults, both major and linking structures, are normal with steep southerly dips, but some are reverse faults of considerable displacement.

Ore Occurrence: The principal ore shoots occur within bleached or hydrothermally altered zones as a result of fissure filling and replacement along faults and fracture zones. Although irregular in detail, the large orebodies are lenticular in outline and are noted for their great vertical extent and continuity. The outstanding example of this great vertical range is the Morning Star vein near Mullan which has been stoped continuously from the surface for a vertical depth of more than 6500 ft.

The Lucky Friday mine area is within a block of ground bounded on the south by the Osburn fault and on the north by a parallel westerly-striking structure mapped by the USGS as the White Ledge fault. The rocks within this block are strongly folded but in general strike east and dip steeply towards the south.

Locally, and particularly in the vicinity of the vein, the bedding is highly contorted and warped. The principal rocks in the vicinity of the mine are argillites and quartzites of the St. Regis and Revett formations. Some purplish-gray argillite of the St. Regis formation is exposed in the footwall of the vein on the 1400 level, but for the most part the original colors of the rock have been destroyed by intense alteration and the rocks in the vicinity of the vein throughout most of the mine area are light greenish-gray, light tan to buff, or white.

The Vein: The Lucky Friday vein has been followed horizontally on the 2000 level and lower levels for about 1400 ft and developed through a vertical range of 2700 ft from the surface to the 2450 level. The main portion of the vein has an average strike of N 65° E that is remarkably constant from the tunnel level to the lowest levels of the mine. Below the 1600 level, however, the vein lengthens both easterly and westerly and these extensions deviate from the general strike. The westerly portion strikes about N 65° W and the easterly extension of the vein strikes north to N 30° E. The vein is locally irregular in strike, particularly in the northeasterly part where it is offset by numerous southeasterly-trending cross faults. The horizontal displacement of the vein by these faults is generally less than 5 ft and the greatest displacement is about 100 ft on a fault near the easterly end of the vein on the 1800 level. Little if any displacement on the same fault was noted on the 2300 level, however.

The vein dips southerly, the dips ranging from vertical to as flat as 45°, with an average dip of 78° from the tunnel level to the 2450 level. Below the 1800 level in the easterly section of the mine the vein dips steep to vertical and reverses dip.

The vein is characterized by a single persistent fault fissure that has been variably replaced by galena and quartz with subordinate amounts of tetrahedrite, sphalerite, pyrite, chalcopyrite, and siderite. Small amounts of pyrargyrite (ruby-silver) and jamesonite have been found in the westerly section of the vein and in a small hanging wall vein. The main strand of sulfide, usually high-grade galena, varies in width from less than an inch to more than 8 ft. Irregular stringers and pods of galena and other sulfides usually accompany the main strand in one or sometimes both walls of the vein. In places of intense fracturing and silicification very fine-grained galena and tetrahedrite are disseminated in the wallrock for several feet on either side of the vein. Similar disseminations of galena and tetrahedrite are present as a replacement of certain favorable quartzite beds for distances of tens of feet away from the vein.

In the upper levels of the mine the vein was explored and developed for lengths of 300 ft or less and the ore shoots above the 1200 level were generally less than 100 ft long. (On the 500 level the orebody was 50 ft long.) The shoots were very persistent in vertical range, however, and below the 1400 level the orebody lengthened horizontally with each successively lower level to a total mineable length of 1113 ft on the 2300 level. This includes an ore shoot 168 ft long on the westerly extension of the vein and the 945-ft long orebody on the main vein. As of January 1958, drift development on the 2450 level had opened a continuously mineable section of ore 1195 ft long and the easterly limit of the orebody had not yet been reached. The westerly extension of the vein has not yet been completely developed on the 2450 level, and a new level, the 2600, is being developed.

Development work in the lower levels of the mine has shown considerable improvement in width and grade as well as in the length of the orebody as compared with the shorter ore shoots in the upper part of the mine. The average stoping width in the main portion of the vein below the 2000 level is about 7 ft, while narrow widths of 4 to 6 ft are maintained in parts of the westerly and easterly extensions of the vein. The average tenor of ore for the past three years based on mill head assays was 17.9 oz Au, 8.8 pct Pb, and 1.4 pct Zn.

Ore reserves have been estimated to provide 19.2 years of operation beyond February 1958 based on the average yearly production of 40,000 tons maintained at the present time. This ore reserve is based on the recent development work completed on the 2450 level.

Many favorable geologic factors point to a promising future for the Lucky Friday mine. Most significant, perhaps, in a general way, are the deep-seated characteristics of the Coeur d'Alene district orebodies. The major orebodies of the district range in strike length from 1000 to as much as 4000 ft and are noted for their great vertical extent and continuity. In applying this generalization to the Lucky Friday mine, it is of particular interest to note:

First, the strike length of the ore shoot has lengthened on each succeeding deeper level; on the lowest developed level, the 2450, the ore shoot is more than 1000 ft long and drifting has not as yet reached the limits of this shoot.

Second, the bleached argillaceous and quartzitic rocks of the Revett formation exposed in the bottom levels of the Lucky Friday mine are among the most favorable host rocks for ore in the district. The relationship of the attitude of the bedding and vein is such that favorable host rock can be expected to great depth.

Third, the Lucky Friday ore has an excellent silver-lead ratio and is not exceptionally high in zinc. Work thus far has shown no appreciable mineralogical zoning in the orebody and no increase in the iron-zinc ratio with depth.

Discussion of this article sent (2 copies) to AIME before Jan. 31, 1959, will be published in MINING ENGINEERING.

• *Magnetic separation was first applied commercially to Mesabi Range taconite at Babbitt, Minn.,*[1] *in 1922. The venture was premature, and development lapsed until 1940-1945, when the Erie and Reserve mining companies and the Oliver Iron Mining Div. of U. S. Steel sponsored 1 and 2-tph pilot investigations, directed by E. W. Davis at the Minnesota Mines Experiment Station.*

• *This was followed by Erie's 2000-ton preliminary taconite plant at Aurora, Minn., in 1948; Reserve's 3000-ton pilot plant at Babbitt in 1952,*[2,3] *and Oliver's 6000-ton Pilotac operation at Mountain Iron in 1953. (These capacities are nominal and are expressed in long tons of crude ore per day.) Magnetic separation technology and machine designs were adopted from operations in eastern U. S.*[4] *and Scandinavia.*[5,6]

• *The pilot plant investigations led to construction of two commercial taconite plants. The E. W. Davis Works of Reserve Mining Co., with a nominal capacity of 3.75 million tons of pellets per year, got under way in 1955,*[7] *and Erie's 7.5-million ton plant began operation two years later.*[8]

MAGNETIC SEPARATION FOR MESABI MAGNETITE TACONITE

By J. E. FORCIEA, L. G. HENDRICKSON, and O. E. PALASVIRTA

All pilot and commercial plants working with Mesabi Range taconite employ wet magnetic separation. Progress is being made with a dry magnetic process,[9-11] but this has not yet been applied to taconite except in the laboratory and pilot plants.

Flowsheets in all five plants are similar, including multiple stages of grinding, each followed by magnetic separation, which rejects a finished tailing. The flowsheet in Fig. 1 is used in the preliminary and commercial plants of the Erie and Reserve mining companies and in Unit C of Oliver's Pilotac plant. At Erie the desliming operation is omitted. In the Reserve plants two ball mills are used with each rod mill. Pilotac uses flowsheet 2 in Unit A-B and has also tested flowsheet 3. Principal differences in the three flowsheets are the number of grinding stages and the type of roughing. The terms *open-circuit roughing* and *closed-circuit roughing* are best defined by the diagrams.

Special Test Data Given in Table I: For the Erie and Reserve commercial plants, Table I reflects routine conditions. Pilotac, the experimental plant, has been run with several flowsheets, including those followed at Erie and Reserve's commercial operations. Pilotac data for these last two flowsheets are similar to commercial plant results and are not repeated in Table I; statistics are given, however, for special test conditions, using other flowsheets, when the objective was to produce extra-grade concentrate.

Variations Among Taconites: Although crude ore tributary to these plants is generally classified as taconite, there are important differences in mineralogy and fineness of dissemination.

J. E. FORCIEA, L. G. HENDRICKSON, and O. E. PALASVIRTA, Members AIME, are, respectively, Development Engineer, Oliver Iron Mining Div., U. S. Steel Corp., Pilotac Plant, Mountain Iron, Minn.; Supervisor of Field Development, Pilotac Plant, Mountain Iron, Minn., and Development Engineer, Research Laboratory, Duluth. TP 4777B. Manuscript, April 30, 1958. N. Y. Meeting, February 1958.

Table I. Magnetic Separation

Flowsheet	Erie Mining Co. Commercial Plant — Two-Stage Grinding, Closed-Circuit Roughing with No Desliming (See Fig. 1)			Reserve Mining Co., E. W. Davis Works — Two-Stage Grinding, Closed-Circuit Roughing with Desliming (See Fig. 1)		
Service designation	Cobbing	Roughing	Finishing	Cobbing	Roughing	Finishing
Grinding machine preceding	Rod mill	Ball mill	Ball mill	Rod mill	Ball mill	Ball mill
Sizing device preceding:						
Type	Screen	Trommel	Cyclones	Trommel	Trommel	Cyclones
Size opening	¼ in.	¼ in.	—	⅝ in.	—	—
Feed:						
Source	Rod mill disch.	Ball mill disch.	Cyclone o'flow	Rod mill disch.	Ball mill disch.	Deslimer u'flow
Size	14 pct +8M; 30 pct −100M	1 pct +14M; 55 pct −100M	1 pct +100M; 75 pct −325M	−¼ in.	—	85 to 90 pct −325M
Solids, pct	55.5	60	22	—	—	—
Ltph/foot magnet width	12.5	18 to 20	2.5	18 to 20	12-14	3 to 3.5
Concentrate solids, pct	72	65	55	—	—	—
Magnetite iron, pct:						
In feed	22.0	49.5(B) (38.0)(C)	51.0	24.5	—	—
In concentrate	38.0	52.0(B) (51.0)(C)	64.0 (Total Fe)	40	— (53)(C)	64.5(Total Fe)
In tails	1.8	0.8(B) (0.8)(C)	1.2	—	—	—
Recovery	96.3	99.9(B) (99.5)(C)	99.5	—	—	—
Machine, general description (D)	Concurrent drums	Countercurrent drum	Semi-cntrcrnt. drums	Concurrent drums	Linney belt	Semi-cntrcrnt. drums
	Spigot tails disch.	Spigot tails disch.	O'flow tails disch.	Spigot tails disch.		O'flow tails disch.
Number of stages	2	1	3	2	1	2
Manufacturer	Memco	Jeffrey-CPS564	Jeffrey-3SPC-464	Jeffrey	Dings	Dings XW6
Magnet:						
Width, in.	48	60	60	48	48	36
Number of poles	5	5	4	6	10	6
Electro or permanent	Electro	Permanent	Permanent	Electro	Electro	Electro
Field strenth, gauss (A)	700	600	400	—	—	—
D-C excitation:						
Volts	230	None	None	—	—	—
Amperes	40 max	None	None	—	—	—
Field strength control	Rheostats	None	None	By voltage control	Rheostat	By voltage control
Drum or belt speed, fpm	189	189	251—1st; 180—2nd and 3rd	—	—	—
Drum:						
Diam, in.	36	36	30	36	Belt	30
Bearing type	Ball bearing	Ball bearing	Ball bearing	Ball bearing	Belt	Ball bearing
Shell cover material	Rubber	Rubber	Rubber	Endless rubber belt	Belt	None
Head material	Cast aluminum	Cast aluminum	Cast aluminum	—	Belt	—
Drive, installed horsepower per stage	3	2	1.5	—	—	—

* Steffensen type. **Notes:** 1) Average of middle of pole and middle of gap readings taken 12 in. from end of pole and 2 in. from drum surface. 2) Figures apply to separator feed, which is a circulating load.

Twofold Achievement of Magnetic Separation: Because of the nature of magnetic separation and the characteristics of Mesabi Range taconite, the process has a dual effect—it is the sole method of concentrating, and it greatly reduces grinding costs.

Table I shows that in cobbing −¼ in., about 40 pct of the feed can be rejected as final tailing, and that in roughing an additional 12 to 15 pct is rejected, thereby reducing the load on the fine grinding stages. Additional smaller benefits accrue from maximum rejection of gangue early in the flowsheet. It has been found that magnetite lost to tailings is more finely disseminated and would require finer grinding to make grade than average material. Also, the more gangue rejected in cobbing and roughing, the higher the grade of final concentrate for a given finisher separator efficiency and fineness of grind. Finally, it is obvious that if upgrading efficiency is improved in the final separation stage, the required concentrate grade can be produced at a coarser grind.

Variables in Rejection Efficiency: The following discussion will emphasize high rejection efficiency of separation, which is more difficult to achieve than high recovery efficiency.

It is generally held that in a drum-type magnetic separator, almost all separation takes place in the zone where magnetics migrate to the magnet face. As the particles of solids come within the field, the magnetics flocculate, and some nonmagnetics become entrained with them. It is believed that as the magnetics are transported along the magnet face there is very little additional rejection. Some further rejection of very fine gangue particles can be achieved by producing as dry a concentrate as possible or by drawing the collected concentrate through clean water.

Significance of Particle Size: When the magnetic separator and operating conditions are being selected, the principal factor is particle size of feed. As particle size decreases, feed rate must decrease and feed be diluted; magnetic field intensity may be lowered. Particle size also dictates the type of tank that can be used. For example, if the feed contains appreciable quantities of +20-mesh, spigot discharge is generally provided for tailings.

Conditions Governing Rate of Feed: For material of given screen analysis and magnetics content, feed rate is limited by two factors—quantity of solids and volume of pulp. One or the other will become limiting, depending on the desired feed pulp density. Table II shows ranges for feed rates at which satisfactory metallurgical results are achieved at Pilotac, as well as data for maximum feed rates that have been investigated. As feed rate of solids is increased while feed pulp density is held constant, concentrate grade decreases, but iron recovery is almost unaffected. As the volumetric feed rate of pulp is increased while feed rate is held constant

Data from Operating Plants

Flowsheet	Oliver Iron Mining Div., U. S. Steel Corp. — Three-Stage Grinding, Open-Circuit Roughing with Desliming (See Fig. 2)					Pilotac Plant — Three-Stage Grinding, Closed-Circuit Roughing with Desliming (See Fig. 3)		
Service designation	Cobbing		Roughing	Finishing		Cobbing	Roughing	Finishing
Grinding machine preceding	Rod mill		Ball mill	Ball mill			Ball mill	
Sizing device preceding:								
Type	Trommel		Cyclones	Cyclones			Trommel	
Size opening	½ in.		—	—			½ in.	
Feed:								
Source	Rod mill disch.		Cyclone o'flow	Deslimer u'flow			Ball mill disch.	
Size	50 pct −20M		50 pct −270M	85 pct −270M			20 pct −270M	
Solids, pct	35		40	25			50	
Ltph/foot magnet width	20		13	2.5			22	
Concentrate solids, pct	70		55	55			55	
Magnetite iron, pct:								
In feed	23		38	61			45 (B) (38) (C)	57
In concentrate	38		58	65.7			48 (B) (49) (C)	65.7
In tails	2.0		0.8	1.5			1.5 (B) (1.5) (C)	1.5
Recovery	96.5		99.3	99.8			99.7 (B) (99.0) (C)	99.5
Machine, general description (D)	Concurrent drums		Semi-cntrcrnt. drums	Semi-cntrcrnt. drums[a]			Countercurrent drums[a]	
Number of stages	Spigot tails disch. 2		O'flow tails disch. 3	O'flow tails disch. 3			Spigot tails disch. 1	
Manufacturer	1st Stage Jeffrey-C740	2nd Stage Dings XW3	Memco DA	Memco DA			Jeffrey-CS551	
Magnet:								
Width, in.	36	48	72	72			48	
Number of poles	7	3	4	4			5	
Electro or permanent	Electro	Electro	2 electro, 1 permanent	2 electro, 1 permanent			Electro	
Field strength, gauss (A)	600	550	600	500	600	500	700	
D-C excitation:								
Volts	230	230	230	—	230	—	230	
Amperes	31	11	19	—	19	—	43	
Field strength control	None used	None used	None used		None used		None used	
Drum or belt speed, fpm	200	200	200		200		200	
Drum:								
Diam, in.	36	24	30		30		36	
Bearing type	Sleeve	Ball bearing	Sleeve		Sleeve		Sleeve	
Shell cover material	⅛-in. stainless	⅛-in. stainless	⅛-in. stainless		None		⅛-in. stainless	
Head material	Cast aluminum	Bronze	Bronze		Bronze		Cast aluminum	
Drive, installed horsepower per stage	3	2	5		5		2	

[a] Same as for three-stage grinding, open-circuit roughing flowsheet, Fig. 2.

[a] Same as for three-stage grinding, closed-circuit roughing flowsheet, Fig. 3.

3) Figures apply to new ball mill feed and show overall performance of the closed-circuit roughing.
4) Where spigot tails discharge is stated, overflow facilities are also provided.

(i.e., by reduction of pulp density) concentrate grade tends to rise, but iron recovery falls somewhat owing to increased losses in fine sizes.

IMPROVING CONTROL

Multiple-Stage Separation: Concentrate grade is improved by multiple stages of separation in series. All Mesabi Range taconite plants employ two stages of cobbing; in the second stage, 7 to 15 pct of the first stage concentrate weight is rejected to tailing. Reserve Mining Co. is installing a third stage of cobber magnetic separators. In the case of the closed-circuit roughing flowsheet, only single-stage separators are used, but since the feed includes the ball mill circulating load, three to four stages of separation are actually performed. Three stages of separation are desirable for open-circuit roughing and for finishing.

Gains and Losses with Pulp Dilution: As the percent solids in feed decreases, grade of concentrate improves, but iron losses tend to increase in the finer sizes. This increase occurs because: 1) higher shearing forces act against the magnetic pull on the particles and 2) in a dilute pulp there is less chance of magnetic flocculation, which is essential to recovery of fine particles. At high pulp density of feed, concentrate grade decreases because nonmagnetic or weakly magnetic particles are mechanically entrained in the matte of magnetic particles that forms at the separator collecting surface. With regard to concentrate grade and recovery, feed pulp densities of 20 to 25 pct would be most desirable, but because of other factors such as water consumption and separator volumetric capacity, higher densities are used in separations on coarse materials. Table II shows feed densities that have been found satisfactory at Pilotac.

Field Strength Tested at Pilotac: As indicated earlier, higher field intensity is required for coarser feed. Field intensities found satisfactory at Pilotac are given in Table II. These values are averages of center of pole and center of gap readings taken at least 12 in. from the end of the magnet and 2 in. away from the shell. For a 5-pole magnet, this would be the average of nine readings.

Field intensities specified apply to unoxidized magnetite taconite. If some of the magnetite has been converted to hematite by oxidation, higher field strengths are required. If as much as 20 pct of the magnetite is oxidized, recovery is noticeably reduced.

Provisions have been made for varying the field intensity of cobbers and roughers in the Reserve plant and cobbers in the Erie plant. The field intensity is decreased at times in order to reject to tailings more of a weakly magnetic middling. This improves concentrate grade, possibly with some small loss in iron recovery. When field intensity is

reduced at Pilotac, the same result is not achieved, possibly because of differences in mineralogy.

Effect of Belt or Drum Speed: Satisfactory results can be achieved with belt or drum speeds varying from 150 to 250 fpm. High speeds produce wetter and therefore dirtier concentrate. Low speeds reduce machine capacity.

SEPARATOR DESIGN

To a great extent feed particle size governs the type of separator tank that can be used, but within these limitations, the following design features are generally applicable.

Overflow discharge of tailings is desirable, as it insures positive drum submergence, but if the feed is coarser than about 20 mesh, there is a tendency for the tank to sand up, and spigot as well as overflow discharge must be provided for tailings.

Pulp must be presented to the magnet so that all magnetics come very close to the magnet poles. It should therefore be in a state of turbulence as it reaches the pick-up zone. This problem, which is most serious in concurrent-type drums, is overcome by installation of rubber vanes or a step on the feed pan at right angles to the flow at the point where pulp enters the magnetic field. With countercurrent and semi-countercurrent tanks like the Steffensen, this problem does not arise, since tailings must pass a considerable magnet arc before discharging. All types should be designed to prevent flow of pulp around the end of the magnet.

Underwater sprays should be avoided. It is difficult to keep them open and to see whether they are functioning.

Tank designs favored at Pilotac are shown in Figs. 4-6. Fig. 4, showing a concurrent separator suitable for cobbing, illustrates a step on the feed pan to produce turbulence at the point of pick-up. Rubber vanes are equally effective. Fig. 6 shows a semi-countercurrent separator suitable for open-circuit roughing or finishing.

The drum diameter must be large enough to contain a magnet that will produce the required field strength. For cobbers and closed-circuit roughers, 36-in. diam drums are used. However, indications are that 30-in. diam may be sufficient for second and third stages of cobbing and also for closed-circuit roughers. Reasonably good results are achieved with 24-in. diam drums as second-stage cobbers at Pilotac. For open-circuit roughers and finishers 30-in. diam drums are satisfactory. Some cost saving can be effected with smaller drums. In Scandinavian practice, 24-in. drums are now used almost exclusively.

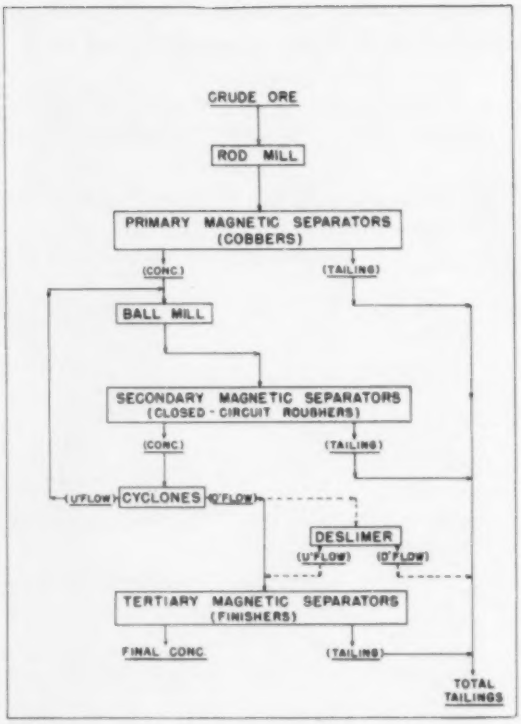


Fig. 1—Two-stage grinding with closed-circuit roughing.

Drums may be at least 6 ft wide (magnet width). Six-foot cobbers of 36-in. diam have been operated at Pilotac for two years, and now that initial bearing trouble has been eliminated performance is satisfactory. A finisher 6 ft x 30 in. has operated a year without trouble. With machines 6 ft wide, results are better when feed is introduced at two points.

The number of poles in the magnet is not important as long as the desired field is developed over the arc required for transportation of magnetics in a tank of the type selected.

Permanent magnets have been proved practical and can be used instead of electromagnets when field strengths of 600 gausses or less are required, but they are not applicable if field intensity must be varied. The principal advantage is that electrical maintenance of magnets is eliminated.

The foregoing remarks apply to metallurgical aspects of separator design. However, because of the vital role of separators, features affecting the operation and maintenance are equally important. Such

Table II. Satisfactory Conditions That Apply at Pilotac Plant

Type of Service	Properties of Feed		Feed Rate Per Foot of Magnet Width				Satisfactory Feed, Solids, Pct	Recommended Tank Design	Satisfactory Field Strength, Gausses
			Pulp, Gpm		Feed, Ltph				
	Size	Mag. Fe, Pct	Maximum	Satisfactory	Maximum	Satisfactory			
Cobbing	50 to 60 pct −20 mesh	22 to 24	150	75 to 125	20	12 to 18	30 to 40	Concurrent, spigot discharge	600 to 700
Roughing (closed circuit)	50 to 60 pct −100 mesh	48 to 52	125	75 to 100	25	12 to 18	50 to 55	Countercurrent or counter rotation—spigot discharge	600 to 700
Roughing (open circuit in three-stage grinding flowsheet)	40 to 50 pct −270 mesh	38 to 42	125	75 to 100	20	8 to 12	35 to 40	Steffensen type, semi-counter—current-overflow	500 to 600
Finishing	80 to 90 pct −270 mesh	50 to 60	100	40 to 60	6	2 to 3	20 to 25	Steffensen type, semi-counter—current-overflow	400 to 500

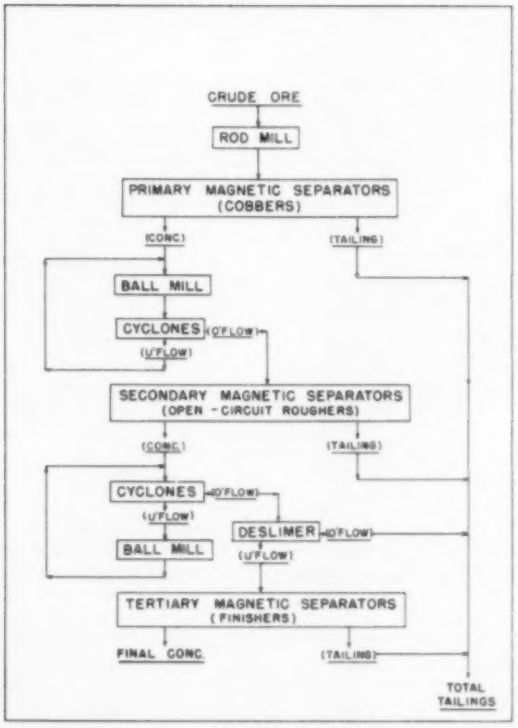


Fig. 2–Three-stage grinding with open-circuit roughing.

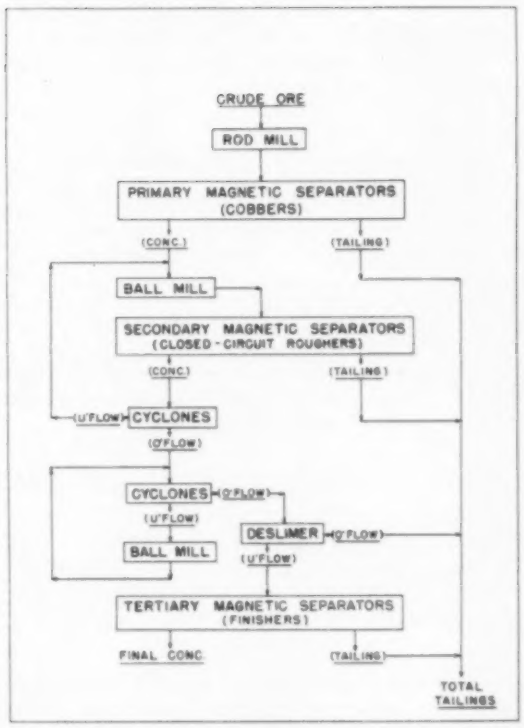


Fig. 3–Three-stage grinding with closed-circuit roughing.

matters could well be the subject of another article and are dealt with very briefly here from the viewpoint of Pilotac experience.

Features Affecting Operation and Maintenance: All wearing parts, such as feed and concentrate pans, should be readily replaceable, and design should provide for positive location of these parts. Drum bearings should be carefully designed, especially with regard to sealing against dirt, and replacement should be possible without removal of drum heads. Sleeve-type bearings with replaceable sleeves on drum and shaft are favored over roller or ball bearings because there is less danger of damaging head and shaft if failure occurs. There is practically no difference in power required to drive sleeve-type and ball-bearing drums.

Stainless steel of the 18-8 type, which is nonmagnetic and corrosion-resistant, is desirable for shell and tank construction throughout, including feed boxes.

Cobber and rougher drum shells at Pilotac are protected with ⅛-in. stainless steel butt-welded covers. Rubber is also satisfactory for roughers and is generally used for finishers.

Drives and bearings should be thoroughly protected against spill and splash.

For drum head construction, bronze is better than aluminum because it corrodes less easily; it is preferred, too, for cobbers and roughers because it resists abrasion.

Desliming, a Phase of Separation: Desliming in this instance may be considered a type of magnetic separation carried out in a hydroseparator. Cyclone overflow is passed through magnetizing coils to flocculate the magnetite, which then settles very rapidly in the hydroseparator, while nonmagnetic gangue may be rejected as overflow.

It is important to maintain the deslimer underflow at maximum density to eliminate as much of the slime-containing liquid as possible. If the

Table III. Davis Tube Test Procedures

Name of Test	Davis Tube −200 Mesh Test	Davis Tube *As Is* Test	Cobber Davis Tube *As Is* Test	Davis Tube −20 +65 Mesh Test
Abbreviation	D.T. −200M	D.T. *As Is*	Cobber D.T. *As Is*	D.T. −20 +65M
Origin of sample	Any material	Any material	Cobber concentrate	Crude ore crushed through ¼ in.
Preparation of sample	Pulverize all through 200 mesh screen.	No preparation. Use *As Received* or *As Is*.	Discard +4 and mesh fraction and run test on −4 mesh. Otherwise *As Is*.	Screen out −20 +65 mesh fraction and use this fraction for test.
Sample size	Use sample size that will insure magnetics in tube are not over 10 g. Usually 50 g for tails and 10 g for conc.	Same as for D.T. −200M test.	60 g run in four 15-g batches.	50 g
Testing time, min	2 to 4 min or until tube is clear.	Same as for D.T. −200M test.	2 min	Same as for D.T. −200M test.
Magnet current, amps, d-c	1.7	1.7	1.2	1.7
Tube speed, strokes per min	90	90	100 to 110	90
Water rate, gpm	0.4	0.4	0.6	0.4

Table IV. Use of the Davis Tube *As Is* Test in Analyzing Finisher Performance

Line		Pct
1	Total iron in Davis tube *as is* concentrate made of finisher feed	66.9
2	Total iron in finisher concentrate	66.4
3	Total iron in Davis tube *as is* concentrate made of finisher concentrate	67.2
1-2	Overall difference between the performance of the Davis tube and the plant finisher	0.5
3-2	Amount of free gangue and/or slime (rejectable) left in finisher concentrate	0.8
3-1	Amount of upgrading achieved by finisher through rejection of low-grade middling particles	0.3

Table V. General Specification of Conditions Assumed for Prediction Calculations

Magnetic Separation	Fineness of Grind Preceding	Stages of Separation	Type of Machines
Cobbing	50 pct −20 mesh in cobber conc.	2	Concurrent
Roughing (open circuit)	45 pct −270 mesh in rougher feed	3	Semi-countercurrent, Steffensen type
Finishing	To be determined	3	Semi-countercurrent, Steffensen type

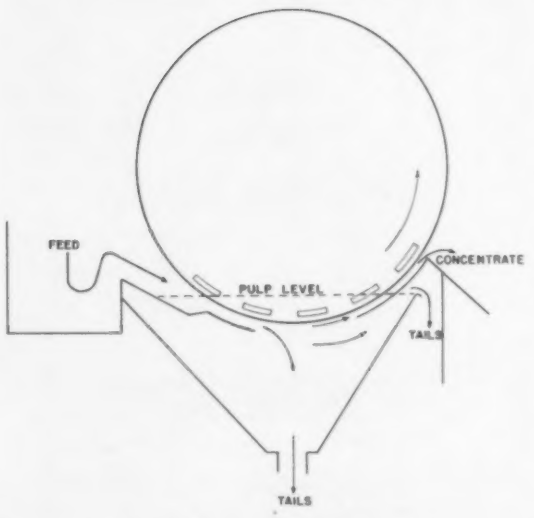


Fig. 4—Tank design in use at Pilotac plant. Concurrent spigot discharge, drum magnetic separator. (Cobber).

underflow is not demagnetized, magnetization of deslimer feed must be carefully controlled. When magnetization is too strong it impairs finisher performance, probably because the magnetic flocs will not release entrained gangue.

Pilotac experimenters found it impractical to control the magnetizing force to suit the needs of both the deslimer and the finishers. The problem was solved by demagnetizing the deslimer underflow, so that feed magnetization could be freed from requirements of the finishers. Demagnetization also greatly improved fluidity of the underflow, which discharged by gravity.

The chief benefit of desliming is thorough rejection of fine gangue. If succeeding finishers are inefficient or overloaded the iron content of finisher concentrate may be increased 1 to 3 pct, but efficient finishers lessen the effect. Rejection of some middling particles can also be achieved by high overflow rates, but some fine magnetite is then lost.

As normally operated at Pilotac, the deslimer underflow is 5 to 8 pct higher in magnetite iron than deslimer feed. The overflow assays about the same in magnetite iron as finisher tails.

SEPARATOR PERFORMANCE

The Davis magnetic tube tester is used extensively to evaluate and predict magnetic separator performance. The procedures for four types of tests, as used at Pilotac, are described in Table III. The essential difference between these tests lies in the origin of samples and the preparation prior to treatment in the Davis tube.

The following quantitative data are obtained:

1) "The percent weight recovery of Davis tube concentrate," a measure of the amount of magnetic material retained in the tube.

2) "The percent weight rejectable," found by subtracting the percent concentrate weight recovery from 100 pct.

3) The percent total iron in the Davis tube concentrate.

Use of the Davis tube is based on the assumption of perfect magnetic separation, that is, retention of all particles containing magnetite and rejection of all particles free of magnetite. The first of these assumptions is not strictly true, but in practice the error has little significance.

Since Mesabi Range taconites commonly contain iron silicates and carbonates, and sometimes hematite, the assay for total iron is not equivalent to that for magnetite iron. It is therefore desirable to determine magnetite iron recoveries by a method that reports magnetite iron only. Pilotac feed, for example, assays 30 pct total Fe, but only 23 pct magnetite; recovery calculations based on total iron would be misleading as to efficiency of magnetic separation.

All taconite plants on the Mesabi Range determine magnetite by the same method. A sample ground to pass 200 mesh is treated in the Davis tube and the concentrate assayed for total iron. The magnetite content is obtained by multiplying the total iron assay by the Davis tube concentrate weight recovery. This method contains certain sources of error, but since the same method is applied to feed, concentrate, and tailing, their effects tend to cancel out in calculations of magnetic iron recovery.

An error of a different type results if the magnetite grains are partially oxidized. In this instance, as the Davis tube has a higher field strength than commercial separators, it will retain as concentrate partially oxidized grains that will be lost in commercial separators. In such cases the magnetite iron content must be determined by chemical means.

Davis tube *as is* tests are used to indicate the ultimate separation possible with a particular size

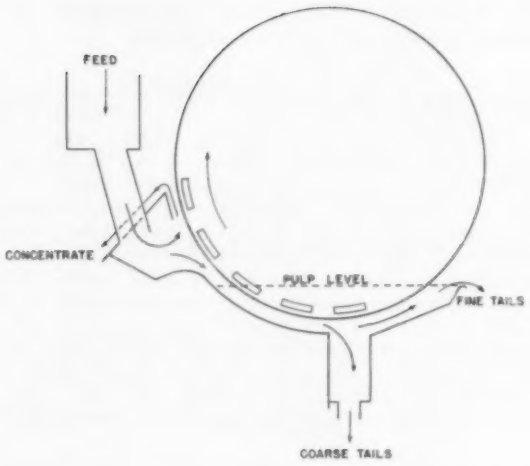


Fig. 5—Design of Pilotac's countercurrent spigot discharge, magnetic separator. (Closed-circuit rougher).

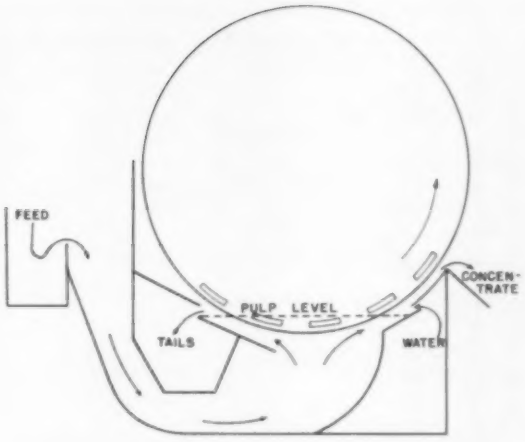


Fig. 6—Semi-countercurrent, full-overflow drum magnetic separator. Suitable for open-circuit roughing or finishing.

consist. Tests of this type also provide a standard of efficiency for commercial separation and reveal the nature of inefficiencies in commercial separators.

The cobber Davis tube *as is* test is usually applied on cobber concentrate to show how much rejectionable material is left in the concentrate by separator inefficiency. Fig. 7, based on data from these tests, indicates that the coarser the cobber feed, the easier it is to produce clean concentrate. This effect could not be illustrated by comparison of concentrate grades only, because better mineral liberation at finer sizes would offset the effect of poorer magnetic separation.

In analyzing rougher performance, the Davis tube *as is* method determines the number of stages needed for effective cobbing.

Finisher performance is judged by essentially the same method. Since it is reasonable to assume that the Davis tube retains practically all magnetite and middling particles, but rejects all slime and liberated gangue, the following conclusions can be drawn:

1) If a given finisher concentrate can be upgraded by treatment, *as is*, in the Davis tube, the difference in total iron assay between finisher concentrate and Davis tube *as is* concentrate can be considered a measure of the amount of fully liberated gangue and/or slime that was retained in the finished concentrate.

2) If the assay of Davis tube *as is* concentrate made from finisher concentrate is higher than the assay of a Davis tube *as is* concentrate made from the finisher feed, the difference is a measure of the amount of upgrading that the finisher achieved by rejecting, presumably, low grade middling particles.

Since these differences are small (see Table IV) conclusions can be drawn only after several tests, but reference to Fig. 8 shows that 1 pct increase in iron assay can save 3 to 4 pct −270 mesh in fineness of grind.

Rejection of low grade middling by cobbers and roughers makes possible a final concentrate of a required grade with less grinding than predicted on the basis of a Davis tube test on a ground crude ore

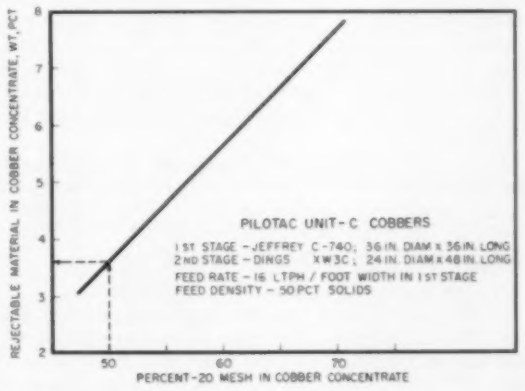

REJECTABLE MATERIAL IN COBBER CONCENTRATE, WT. PCT
8
7
6
5
4
3
2
PILOTAC UNIT-C COBBERS
1 ST STAGE - JEFFREY C-740; 36 IN. DIAM x 36 IN. LONG
2 ND STAGE - DINGS XW3C; 24 IN. DIAM x 48 IN. LONG
FEED RATE - 16 LTPH / FOOT WIDTH IN 1 ST STAGE
FEED DENSITY - 50 PCT SOLIDS
50
60
70
PERCENT-20 MESH IN COBBER CONCENTRATE

Fig. 7—Plotted test results show that the coarser the cobber feed, the easier it is to produce clean concentrate.

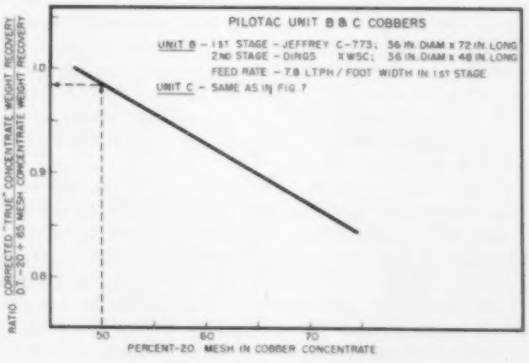

RATIO CORRECTED "TRUE" CONCENTRATE WEIGHT RECOVERY
0/-20 + 65 MESH CONCENTRATE WEIGHT RECOVERY
1.0
0.9
0.8
PILOTAC UNIT B & C COBBERS
UNIT B - 1 ST STAGE - JEFFREY C-773; 36 IN. DIAM x 72 IN. LONG
2 ND STAGE - DINGS XW5C; 36 IN. DIAM x 48 IN. LONG
FEED RATE - 7.8 LTPH / FOOT WIDTH IN 1 ST STAGE
UNIT C - SAME AS IN FIG. 7
50
60
70
PERCENT-20 MESH IN COBBER CONCENTRATE

Fig. 7A—Liberation characteristics for predicting cobber performance are determined from a Davis tube test on the −20 +65 mesh fraction of the crude. Graph shows the relationship that has been established, for Pilotac ore, between these results and the actual plant performance.

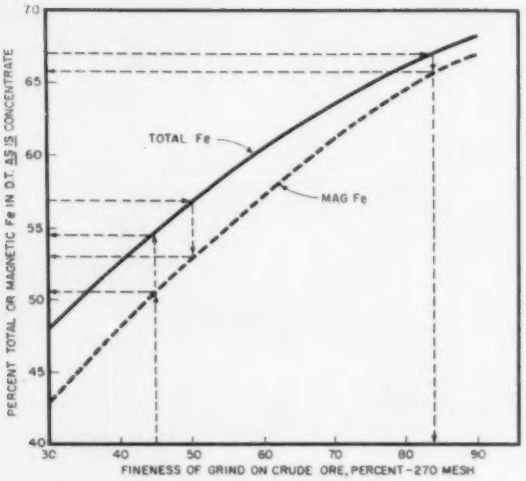


Fig. 8—Liberation characteristics of Pilotac ore sample.

sample. This effect approximately offsets the difference in separation efficiency between the Davis tube and a plant finisher, working on the same feed. For prediction purposes, therefore, the fineness of finisher feed required to produce a certain grade of finisher concentrate may be taken as the grind on crude ore required to produce the grade in the Davis tube.

A somewhat generalized example will illustrate the Pilotac method for predicting performance of a given plant on a given material. The example is based on the following conditions:

1) Flowsheet as in Fig. 2.
2) General conditions as given in Table V.
3) Final concentrate grade required: 67 pct Fe.
4) The assumption (on basis of plant experience) that the magnetite iron recoveries will be 96.5, 99.5, and 99.7 pct in cobbers, roughers, and finishers, respectively.

Liberation characteristics for predicting cobber performance are determined from a Davis tube test on the −20 +65 mesh fraction of the crude. With Pilotac ore, a relationship has been established between these results and actual plant performance. Actual plant weight recovery is corrected by dividing by the magnetite iron recovery and multiplying by the percent weight recovery in the Davis tube *as is* test to give a so-called *corrected true concentrate* weight recovery. The ratio of this to the Davis tube −20 +65 mesh concentrate weight recovery is plotted against the percent −20 mesh in cobber concentrate as shown in Fig. 7A.

If the Davis tube −20 +65 mesh concentrate weight recovery is 60 pct and the cobber concentrate 50 pct −20 mesh, using Fig. 7A, the *corrected true concentrate* weight recovery becomes $0.985 \times 60 = 59.1$ pct. From Fig. 7, the percent rejectable expected in cobber concentrate is found to be 3.6 pct (or 96.4 pct cobber Davis tube *as is* weight recovery). Therefore expected weight recovery becomes

$$59.1 \times \frac{96.5}{96.4} = 59.2 \text{ pct}$$

Assuming that the crude ore assays 23 pct Mag. Fe and the percent magnetite iron recovery is 96.5 pct, then cobber concentrate (rougher feed) will assay

$$\frac{0.965 \times 23}{59.2} = 37.5 \text{ pct Mag. Fe}$$

Liberation data for predicting rougher and finisher performance are developed by controlled grinding tests on crude ore and Davis tube *as is* tests on the ground crude ore. For each product, the total iron and the magnetite iron contents are determined and then liberation curves are drawn, as shown in Fig. 8. According to these curves, the total and magnetite iron assays, corresponding to a grind of 45 pct −270 mesh, are 54.5 pct and 50.5 pct respectively. A correction is again made, allowing for the fact that the plant roughers are capable of rejecting some low grade middling material. Using a corrected figure of 53 pct Mag. Fe for the rougher concentrate, a figure of $0.995 \times \frac{37.5}{53.0} = 70.4$ pct for weight recovery (on basis of rougher feed) is obtained.

From Fig. 8, it is observed that a Davis tube concentrate assaying 67 pct iron can be produced by grinding the crude ore to 84 pct −270 mesh. This, then, is the required grind. Using the magnetite iron assay of 65.7 pct, finisher weight recovery becomes $\frac{0.997 \times 53.0}{65.7} = 80.4$ pct of finisher feed. Overall magnetite iron recovery is $\frac{99.7}{100} \times \frac{99.5}{100} \times 96.5 = 95.7$ pct. Overall weight recovery is $\frac{80.4}{100} \times \frac{70.4}{100} \times 59.2 = 33.5$ pct.

The authors are indebted to F. D. DeVaney of Pickands Mather & Co. for data on the Erie Mining Co. commercial plant. Preparation of this paper was facilitated by the cooperation of all companies engaged in taconite beneficiation. Finally, appreciation is expressed to R. J. Morton and R. L. Bennett of Oliver Iron Mining Div., U. S. Steel Corp., under whose direction the work was done.

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Discussion of this article sent (2 copies) to AIME before Jan. 31, 1959, will be published in MINING ENGINEERING.

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Please list in chronological order a complete record of your employment. Be explicit as to dates, your duties, nature of the work, and the extent to which you were in responsible charge of your own work or of the work of others. Include all positions held, whether or not they are related to the mineral industry. If additional space is needed, use separate sheet of the same size.

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SME BULLETIN BOARD

Reports of Your Technical Society

SME's Annual Meeting
ABSTRACT AND PROGRAM SECTION

NEWSLETTERS . . .
- Coal page 1281
- MBD'ers Digest page 1283
- Rock in the Box page 1285

ATTENTION - - -

SME MEMBERS

Turn over the opposite page for start of SME's Membership Application. Help a professional colleague fill it out and mail to SME.

San Francisco in February 1959

Technical program and abstracts for SME's part in the AIME Annual Meeting begin on page 1241. A final complete program, including social functions and technical events, will be published in January as will be additional abstracts received too late for this issue. MINING ENGINEERING, *in this section, presents a guide to San Francisco (page 1250), AIME's February city. Floor plans (page 1252) of the Sheraton-Palace Hotel, SME headquarters, help orient those planning to attend.*

Proposals For Membership

Change of Address Personals Data Boxes

These forms appear on page 1291 for your convenience.

Spire from St. Louis recalls a Mid-America-October meeting—gay social events and program highlights are reported . . .

page 1288

mining ENGINEERING 1958 INDEX

follows page 1300

Coal loading and dumping towers, similar to these, were some facilities seen in Virginia during the AIME-ASME Joint Solid Fuels Conference . . .

page 1286

SYMPOSIA

Minnesota, January 12 to 14, AIME Minnesota Section annual meeting and University of Minnesota Mining Symposium. **Arizona,** February 23 to 27, March 2 and 3, FluoSolids Symposium, University of Arizona. Page 1279.

The regular Annual Business Meeting of the Institute will be held on Tuesday afternoon, the 17th day of February 1959 following the All-Institute Session at the Annual Meeting of the Institute in San Francisco.

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SME Officers Elected

On Sept. 1, 1958, the officers of the Society of Mining Engineers for 1959 and the officers of the four Divisions were officially declared elected. The SME officers are as follows: *President-Elect*, Arthur B. Cummins; *Vice President* of the Central Regional Area, Donald W. Scott; and *Directors*, James C. Gray, John G. Broughton, William B. Stephenson, Ewald Kipp, and Sherman F. Kelley. The Division officers can be found in the July issue as follows: Coal Division, p. 801; IndMD, p. 803; M&E, p. 805; and MBD, p. 807.

1959 Dues Bills Mailed

Notice is hereby given that dues for the year 1959 are payable Jan. 1, 1959, as follows: Members and Associate Members, $20; Junior Members for the first six years of Junior Membership, $12, and thereafter, $17; Student Members (including an annual subscription to a monthly journal), $4.50.

Dues bills were mailed at the end of November. Prompt payment will assure uninterrupted receipt of the publications desired in 1959. If, for any reason, a bill is not received within a reasonable time, headquarters should be notified.

1958-1959 AIME Awards

The following men have been selected for 1958-1959 AIME awards to be presented at the ceremonies indicated:

William Lawrence Saunders Gold Medal, 1959, to **John B. Knaebel.** AIME Annual Banquet, February 18.

Anthony F. Lucas Gold Medal, 1959, to **John T. Hayward.** AIME Annual Banquet, February 18.

Benjamin F. Fairless Award, 1959, to **J. L. Mauthe.** AIME Annual Banquet, February 18.

Rossiter W. Raymond Award, 1959, to **John J. Gilman.** The Metallurgical Society Dinner, February 17.

Mathewson Gold Medal to **John J. Gilman.** The Metallurgical Society Dinner, February 17.

Robert Peele Memorial Award, 1959, to **Frank R. Jones.** Mining and Exploration Division Luncheon, February 18.

Extractive Metallurgy Division Award, 1959, to **W. A. Krivsky** and **R. Schumann, Jr.,** Extractive Metallurgy Division Luncheon, February 18.

J. E. Johnson, Jr., Award, 1959, to **Clarence T. Marshall.** The Metallurgical Society Dinner, February 17.

Robert Lansing Hardy Gold Medal, 1958, to **Norbert F. Neumann.** This award will be presented at a meeting of the St. Louis Section.

Howe Memorial Lecturer, 1959, Clarence E. Sims. Certificate presented at the lecture, February 17.

Institute of Metals Division Lecturer, 1959, Frederick Seitz. Certificate presented at the lecture, February 18.

Daniel C. Jackling Award and Lecture, 1959, to **Ralph S. Archibald.** Mining and Exploration Division Luncheon, February 18.

Cedric K. Ferguson Medal, 1958, to **Jim Douglas, Jr., Philip M. Blair,** and **R. J. Wagner.** This award was presented at the SPE fall meeting on October 7.

John Franklin Carll Award, 1958, to **Ernest O. Thompson.** This award was also presented at the SPE fall meeting on October 7.

Hal Williams Hardinge Award, 1959, posthumously **Oliver Bowles.** Presentation was to Mrs. Bowles on December 2 at a Washington, D. C., Section meeting.

Mineral Industry Education Award, 1959, to Allison Butts. Council of Education of AIME dinner, February 15.

FluoSolids Reactor To Be Symposium Subject At Arizona University

The University of Arizona College of Mines, Tucson, will sponsor a program and symposium on *The Application of the FluoSolids Reactor to the Mineral Industry.* The first part of the program will be held for five days, from February 23 to 27. It is designed for engineers who will control or be connected with operation of a FluoSolids reactor.

The program will consider fundamentals of chemistry, physics, mathematics, stoichiometry, and metallurgical thermodynamics as they apply to the FluoSolids reactor. The College of Mines has the only 4-in. FluoSolids reactor for instruction.

A symposium will form the second part of the program on March 2 and 3. Technical papers, a panel discussion, and a field trip to the new Hayden smelter of Kennecott Copper Corp. will be included.

The program has been planned to follow the AIME Annual Meeting in San Francisco in response to considerable interest expressed by mineral industry representatives. The fee for the educational program is $30 and the field trip expense will be $10, including one meal. For additional information write to Professor Sigmund L. Smith at the College of Mines, University of Arizona.

Instrumentation And Report on Russia Will Be Minnesota Program

Two subjects of major interest will be discussed at Minnesota meetings in January: Russian mining methods and instrumentation in the mining industry. The Minnesota Section will hold its annual meeting in Duluth on Jan. 12, 1959, and the 20th Annual Mining Symposium sponsored by the University of Minnesota will follow on the 13th and 14th.

At the AIME meeting three men who have recently returned from Russia will present their views on the latest Russian developments in mining. E. L. Joppa, general manager, Pickands Mather & Co., will report on his impression of Russian mining equipment and methods. D. N. Vedensky, director of research and development for The M. A. Hanna Co., will describe the Russian beneficiation methods and plants. And J. H. Strassburger, assistant vice president of Weirton Steel Co., will present a report on Russian steel operations.

In addition, the AIME session will include a report by J. S. Breitenstein on the use of the R-N process for the direct reduction of Mesabi Range iron ores.

Dean Nolte of the Center for Continuation Study of the University of Minnesota reports that the Mining Symposium will begin with a

(*Continued on page 1280*)

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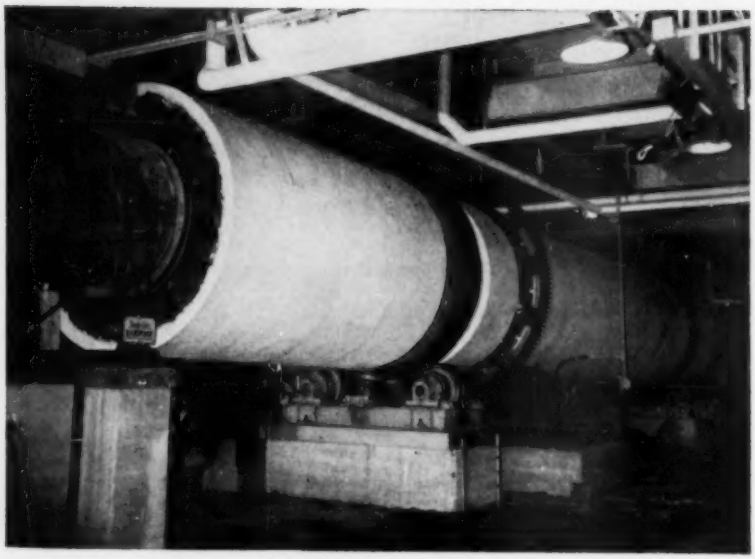

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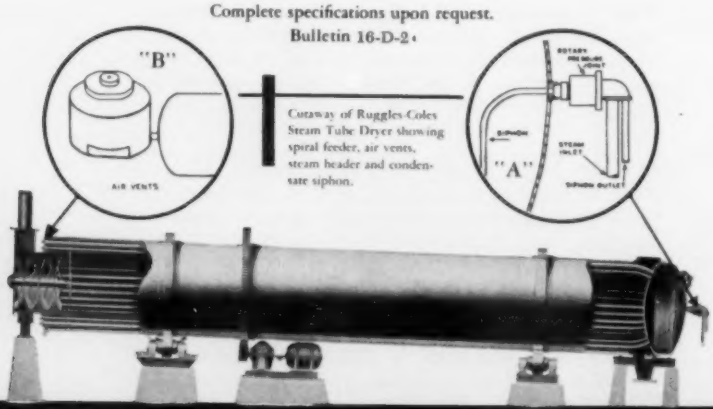
Bulletin 16-D-2.



Cutaway of Ruggles-Coles Steam Tube Dryer showing spiral feeder, air vents, steam header and condensate siphon.

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Education News

Michigan College of Mining & Technology

Michigan College of Mining and Technology announced its largest enrollment in history this fall, with science students nearing the 3000 mark. Even larger enrollments may be possible in the future. New faculty positions have been authorized but funds for them are not yet available. Although the large majority of Michigan Tech's students are state residents, most of the other states and 18 foreign nations are represented in the student body.

Major studies include 17 graduate and undergraduate fields of engineering and science, with about 150 students enrolled in forestry and 200 in business administration. The increase in enrollment of 6 pct is consistent with national trends in science and engineering schools.

University of Nevada

A course in geophysics is being offered for the first time this year at the Mackay School of Mines, University of Nevada. Vernon E. Scheid, dean, said the addition was part of a continuing effort to better serve the mineral industry.

James I. Gimlett will teach the course which includes magnetic, gravimetric, electric, seismic, and radiometric prospecting methods. Professor Gimlett was formerly a geophysicist for Hycon Aerial Surveys Inc. of Pasadena, Calif. He will also be in charge of the University's seismographic station, and will devote a portion of his time to work with the Nevada Bureau of Mines.

Columbia University Fund

The annual Columbia University Engineering Fund is headed this year by John F. Thompson, chairman of the board of International Nickel Co., and Joseph N. Murray, retired consulting electrical engineer. Unrestricted funds are to be raised for the Columbia School of Engineering.

Minnesota Symposium

(Continued from page 1279)

discussion of instrumentation in general and its application to the mining industry. Two subsequent sessions will cover instrumentation in beneficiation, and instrumentation in mining. For additional information address the Center for Continuation Study, General Extension Div., University of Minnesota, Minneapolis 14, Minn.

Leading U. S. Mining Schools . . .

VIRGINIA POLYTECHNIC INSTITUTE

From time to time the Coal Division will offer on this page brief profiles of the nation's top coal mining schools—the institutions on which the industry must depend for its future leaders and which are the basis of its future progress. A close relationship with your schools is vitally important. Knowing them is the first step.

The following information was supplied by C. T. Holland, professor and head, Dept. of Mining Engineering, Virginia Polytechnic Institute, Blacksburg, Va.

Matriculating in Mining at VPI

VPI's records indicate that somewhere between 65 and 75 pct of its graduates in mining have sought their first jobs in the coal industry in Virginia and adjoining states, and the majority are still so employed.

Enrollment of graduates and undergraduate students for 1958-1959 is expected to total about 50 to 55.

Curriculum

The curriculum at present consists of a general course in mining engineering with rather strong emphasis on coal mining and a less general optional course in which mineral fuels are stressed.

The curriculum is now being revised and, beginning 1959-1960, it is planned to offer a general course in mining engineering with specialization in the senior year through selection of electives. A student, for example, may elect to specialize in coal mining engineering by selecting a coal mining design problem and two specific courses pertaining to coal mining. If he wishes to specialize in metal mining he will do additional work in geology and select a design problem involving metal mining operations. In the junior year, a student may follow a curriculum heavy in geology and geophysics to work toward specialization in mining exploration and prospecting.

Graduate work will continue with principal emphasis on mining methods, roof control, mineral beneficiation, and mine ventilation. It is believed the options in the curriculum will make the course more versatile.

Research

For many years the department has maintained an active research program within the department and through the Virginia Engineering Experiment Station. Projects sponsored by industries are handled through the Station on a cost plus basis and arrangements can be made for any worthwhile project on this basis by industries located in Virginia as well as outside the state. The projects within the department are carried on by staff members and by graduate students. At present projects are underway involving washability of Virginia coals, beneficiation of kyanite, beneficiation of the sulfide ores of Carroll County, properties of stopping materials used in mine ventilation systems, and roof and pillar action in coal mines.

Holden Hall, home of VPI's Mining Engineering Dept., also houses the departments of geology and metallurgy.

Undergraduate students are used as project assistants as much as possible. Using undergraduates serves two purposes: 1) it enables them to learn through direct participation in research and 2) it enables them to earn part of their college expenses.

Good Location

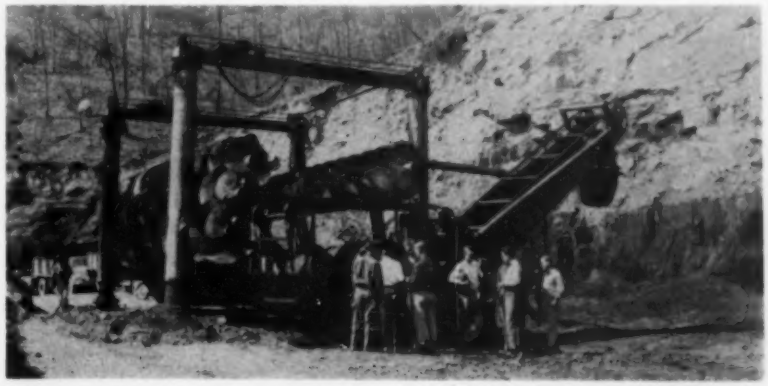
The mining department is located at Blacksburg in southwestern Virginia and is within three hours drive by automobile to extensive coal mining operations, oil and gas operations, metal mining operations, and nonmetallic operations. Ample advantage is taken of this location by arranging several inspection trips a year to large mining operations.

Staff

The department has three full time professors with extensive industrial experience, plus graduate and undergraduate assistants. A favorable ratio of staff members to students permits students to receive individual attention when necessary. All staff members participate in research and have individual projects.

AIME Chapter

The Burkhart Mining Society is the student chapter of AIME at VPI. It was organized about 1940 and has been active since then. Each year the society arranges to bring in one or two speakers to talk on special phases of mining. Membership now includes about 40 students.



VPI seniors in mining engineering are schooled on fine points of auger coal mining on properties of Clinchfield Coal Corp. near Dante, Va., during a VPI inspection trip.

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AIME NEWS

1959 AIME Publication Prices Are Determined

The following price information has been announced for AIME publications in 1959:

If payment for AIME *Transactions* volumes is made with dues, the cost per subscription is: *Mining*, $3.50; *Metals*, $5.00; and *Petroleum*, $3.50. If payment is made separately, the cost is: *Mining*, $4.90; *Metals*, $5.00; and *Petroleum*, $4.90.

If another journal (published by a different Society) is desired, in addition to the subscription received upon payment of annual dues (to the AIME Society of your choice), the additional monthly journal will cost $4.00.

A second subscription to any journal to which you are now subscribing costs $8.00.

Petroleum Statistics: Volume 12, published in December 1958, costs $7.50 if paid with dues, $10.50 if ordered later.

Bimonthly *Transactions of The Metallurgical Society of AIME* member subscription price is $5.00.

1959 AIME Officers

At the November AIME Board of Directors Meeting, the officers of AIME for 1959, and five other Directors named to take office for three-year terms in that year, were officially declared elected. They are as follows: *President-Elect*, Joseph L. Gillson; *Vice Presidents and Directors*, Elmer A. Jones, Thomas C. Frick, Walter R. Hibbard, Jr., and J. C. Kinnear, Jr.; *Directors*, Arthur B. Cummins, J. W. Woomer, John S. Bell, John Chipman, and C. C. Long.

AIME Names 1959 Legion of Honor List

Each year at the Annual Banquet in February, those members of the AIME who have continuously maintained their membership for 50 years are given special recognition. They are seated at the head table as guests of the Institute and are added to the membership of the Legion of Honor. Those who will achieve this status in 1959 are:

Allen, Roy H.
Banning, Calif.

Bancroft, Howland
New York

Berg, H. A.
Birmingham

Burchard, E. F.
Washington, D. C.

Busey, A. P., Jr.
Burlingame, Calif.

Herz, Nathaniel
Lead, S. D.

Irwin, David D.
Winnetka, Ill.

Jackman, Herbert E.
Rochester, N. Y.

Jenks, Norman L.
Narino, Colombia

Lassiter, Robert G.
Ashe City, N. C.

McAuliffe, Eugene
Omaha, Neb.

McCart, Robert, Jr.
Fort Worth, Texas

Ruggles, Guy H.
Cananea, Mexico

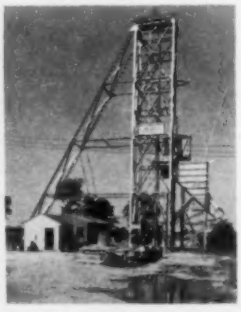
Rutherford, William P.
Glasgow, Scotland

Sayre, Mortimer F.
Schenectady, N. Y.

Smith, H. Dewitt
New York

Soper, E. K.
Los Angeles

Wolf, Albert G.
Houston



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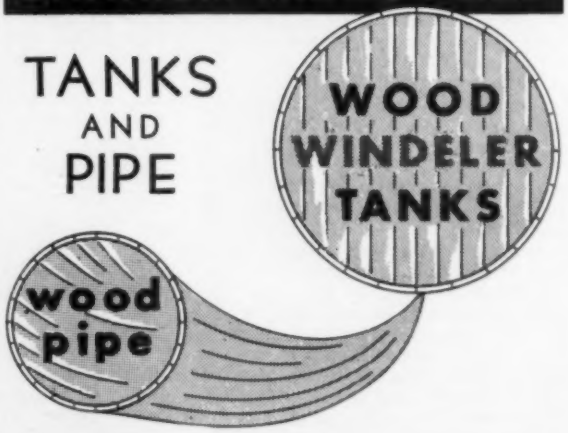

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MBd'ers digest

MBD and the Annual Meeting are covered in the SME Abstract and Program Section on page 1241.

Commemoration of the 50th Anniversary of Froth Flotation in the U. S. will take place in 1961, Sept. 6 through 9, in Denver. Behind-the-scenes arrangements have begun and a progress report in now available. J. D. Vincent is chairman of the executive committee, responsible for plans of the various committees.

Under the chairmanship of Gordon H. Poole, the program committee has set up regional chairmen in the U. S. and throughout the world. They have arranged for sessions to cover 2½ days with 20 papers in five separate meetings. There may be a need for simultaneous sessions if the number of worthwhile papers continues to increase. The program committee will work out this problem during the next two years, until the schedule takes its final form.

The editorial committee, under D. W. Fuerstenau, has been developing an outline for the proposed Memorial Volume. Mr. Fuerstenau is in the process of collecting suggestions before the committee proposes a final outline. When that is completed, the committee will turn to the job of suggesting authors.

The chairman reported progress in a letter dated August 14:

> The consensus is to publish a volume that will be of general interest to all flotation engineers. Certain chapters will be of specific interest to select groups, such as plant operators, design engineers, scientists,; educators, and students. Material now covered in texts should not be included. Considerable progress will have been made by 1961, so that there will be much new material. Consequently, the book will discuss practice and theory according to 1961 concepts. The temporary outline, which certainly is not definite yet, includes the following breakdown of chapters: two history, three general, four theory, four engineering, and eight practice.

Anniversary meeting arrangements are being taken care of by Norman L. Weiss of the executive committee and William Ahlborg. Rooms have been reserved at the Cosmopolitan and the Brown Palace Hotels in Denver. The banquet will be held in the Lincoln Room of the Shirley Savoy Hotel.

Report of the financial committee, under D. W. Scott, chairman, has been delayed pending the editorial committee report on the outline and estimate of the Memorial Volume. Mr. Scott will make his recommendations for financing the volume. He will choose members for a financial committee who can solicit backing from individuals, corporations, endowment fund groups, or from any other source that he deems necessary.

In addition to committee chairmen and members already mentioned, executive committee members who are guiding the preliminary plans are: S. D. Michaelson, D. W. McGlashan, S. R. Zimmerley, E. H. Crabtree, W. B. Stephenson, and N. Arbiter.

The advisory board consists of the following members: H. R. Banks, Lyle M. Barker, Thomas G. Chapman, A. W. Fahrenwald, A. M. Gaudin, Pierre Hines, G. McLachlan, Jack Myers, H. A. Pearse, Herb Rose, A. F. Taggart, and Guy Ruggles.

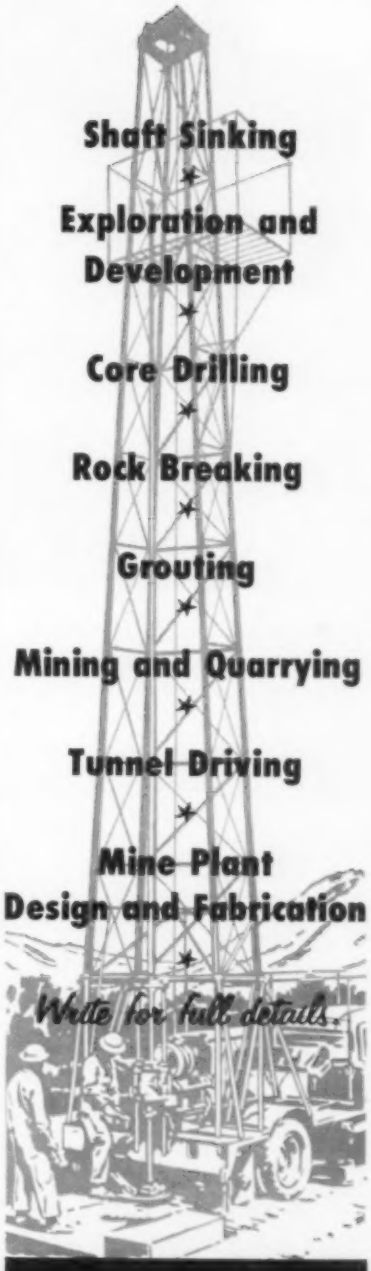
Many aspects of flotation will be considered in the papers presented. Topics under discussion include an early history of flotation, its development in such widespread areas as British Columbia, France, Africa, Peru, and the U. S. The design and development of flotation mills and equipment will probably be covered. There will be papers discussing flotation of specific materials such as lead, zinc, copper, molybdenite, potash, and hematite. The program committee hopes to schedule reports on latest (1961) developments as well as some of the problems of the processes.

Coal flotation as developed in France and techniques needed for western iron ore and coal will be summarized. A number of Russian and Eastern European authors are to be invited to contribute their problems and achievements. Alternating emphasis on broad and specific areas will guarantee a comprehensive conference.

Regional chairmen and the areas they represent are listed below.

United States: *Ballard H. Clemmons*, Alabama, Georgia, Florida, North Carolina, South Carolina, Virginia; *David R. Mitchell*, Pennsylvania, Maryland, New Jersey, New York, New England; *Clarence F. Zeuch*, Michigan, Ohio, Indiana, Kentucky; *R. H. Lowe*, Missouri, Kansas, Oklahoma, Texas; *I. Milton LeBaron*, Illinois, Wisconsin, Iowa, Nebraska; *J. A. McAllister*, Arizona, New Mexico, El Paso area; *Hildreth Frost, Jr.*, Colorado, Wyoming; *Neil Plummer*, Utah, Nevada; *Ralph B. Utt*, California, Washington, Oregon; *Fred D. DeVaney*, Minnesota, Dakotas; *Donald W. McGlashan*, research; *Joseph Newton*, Eastern Washington, Idaho, Montana.

Foreign: *Van H. Smith*, Canada; *George M. Potter*, Mexico, Central America; *Maurice R. W. Rey*, France, French Union, Low Countries; *A. Gotte*, West Germany; *Walter F. Meckel*, Alto Plano Region of South America; *Edmund J. Pryor*, Great Britain; *Per G. Kihlstedt*, Sweden, Denmark, Norway.



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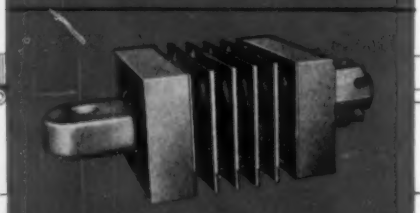

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Mining & Exploration Division

F. R. Jones Wins 1959 Robert Peele Award

The Robert Peele Memorial Award for 1959 has been awarded to F. R. Jones, mine manager, Stanrock Uranium Mines Ltd. in Elliot Lake, Ont., Canada. It will be officially presented to Mr. Jones at the Mining and Exploration Division Luncheon during the AIME Annual Meeting on Wednesday, Feb. 18, 1959, in San Francisco.

Mr. Jones has earned this honor for his paper entitled *More Rock Per Dollar From the MacIntyre Pit* (TP 4228A) which was presented at the New York Annual Meeting, February 1956. His paper was published in MINING ENGINEERING, *Transactions*, May 1956. At the time the paper was written, Mr. Jones was mine superintendent, MacIntyre Development, Titanium Div., National Lead Co., in Tahawus, N. Y.

Ray Jones was born in 1916 in British Columbia on the banks of the Horsefly River, where the first discovery of placer gold had earlier precipitated the Cariboo gold rush. He moved to Victoria when he was seven, and attended public school and high school in Saanich Municipality. His first two years of university were spent at Victoria College. From there he went on to graduate from the University of British Columbia with a B.A. in 1938, a B.A.Sc. in mining engineering with honors in 1939, and completed work for an M.A.Sc. in 1946.

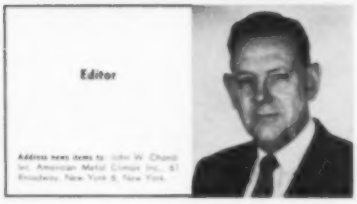
During the summers and for one complete year Ray Jones worked underground for Britannia Mining and Smelting Co. After graduation he also worked for this company in various capacities in engineering and mine supervision until 1943. At that time he enlisted in the Canadian Active Army as a private and was discharged as Lieutenant, R. C. E., in 1945.

Mr. Jones held several positions after his Army duty, including mine superintendent and chief engineer at Polaris Taku, mine superintendent at Van Roi, and superintendent at Reeves MacDonald. While still in British Columbia he was also manager at Grant Mascot, and chief engineer at Canadian Exploration. It was after this variety of experience that Ray Jones came to New York, as mine superintendent and general superintendent of the MacIntyre Development.

In addition to his membership in AIME, Mr. Jones has been chairman of the Algoma Branch of CIM and member of the Assn. of Professional Engineers of British Columbia and Ontario Provinces.

Robert Peele Award

One of the features of the various Division activities is presentation of special awards recognizing a particular talent or service to the industry. The Robert Peele Award was established in 1953 by the then Mining, Geology, and Geophysics Division (now Mining and Exploration Division) of AIME in honor of the distinguished mining engineer, educator, and author for whom it was named. The award is given for the most outstanding paper on a mining, geology, or geophysics subject published in the *Transactions* during the period under review. One or more of the authors must be AIME members not over 40 years of age at the time the paper was submitted to the Institute for publication.



Papers are judged for the award on the following basis:

1) For significance of contribution to the engineering literature of metal mining, geology, or geophysics.

2) For the excellence of technical writing. The papers must be an original contribution of permanent interest and of practical or technical value. AIME publication of the paper is required and more than one author may qualify.

The award consists of a $100 prize and certificate and is presented at the M&E luncheon during the Annual Meeting.

The Peele Award Committee personnel this year includes Rollin Farmin (chairman), E. R. Borcherdt, R. D. Leisk, H. E. McKinstry, Darwin J. Pope, and P. J. Shenon.

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Special Awards and Inspection Trips Spark Fall AIME-ASME Joint Solid Fuels Meeting

The 21st annual AIME-ASME Joint Solid Fuels Conference was held in the Chamberlin Hotel, Old Point Comfort, Va., October 8, 9, and 10, with the Virginia Section of ASME acting as host. The conference was under the joint sponsorship of the Fuels Div., ASME, and the Coal Div. of SME.

The conference theme was *The Export Coal Market*, which was thoroughly covered by papers and field trips. In addition, the ladies had their share of entertainment and informative excursions to Williamsburg and Fort Monroe, with luncheons and a banquet, cocktails, and dancing to round out the program. From the early arrival party to the final technical session the schedule showed coordinated planning and worthwhile results.

Luncheon in the Virginia Room of the Chamberlin Hotel on October 9 welcomed S. Pemberton Hutchinson as principal speaker (top) and George G. Ritchie as toastmaster.

The technical sessions began October 9 on the Roof Garden of the Hotel. In addition to the speakers pictured here, R. C. Tench discussed *Dock Handling of Bulk Materials*. The business luncheon which followed presented the theme of the conference, discussed by S. Pemberton Hutchinson.

In the afternoon, inspection trips viewed the facilities of the Chesapeake and Ohio Railway Co., the Norfolk and Western Railway Co., the Virginian Railway Co., plus the ship building and Naval headquarters. That evening the banquet was the setting for singing entertainment by *The Crusaders*, the presentation of awards, and a talk by C. S. Reed.

The technical session on Friday morning presented papers by A. Burr, C. W. Gordon, H. J. Rose, J. R. Lucas, and W. J. Verner. Carl Dennis and Herbert Lammers were co-chairmen. The afternoon session presented reports on the first cyclone furnace fired boiler in the southeast, and the use of low coke button bituminous coal in anthracite equipment, among other subjects.

Executive committee meetings and breakfast meetings for authors and chairmen completed the program.

A harbor tour covered famous Hampton Roads port, with 200 guests aboard the U. S. Coast Guard Cutter, Cherokee, to view the railroads' coal loading facilities.

Elmer E. Kaiser (left) presented the illuminated certificate of the Percy Nicholls Award for 1958 to Willibald Trinks, with Mrs. Trinks watching proudly. At right, Edward E. Williams conferred the Fellow member grade of ASME on Theodore Baumeister.

A variety of scenes typified the conference. At top, left, General Conference Chairman Ritchie congratulates J. B. Jones, head of the Mechanical Engineering Dept. of Virginia Polytechnic Inst., who received the Fellow member grade of ASME, as J. C. Fox, SME Secretary, looks on. On top at right the banquet speakers snapped during their talks are James N. Landis, president, ASME, and vice president of the Bechtel Corp. who was presiding; and below him, C. S. Reed, principal speaker of the evening who spoke on "Times Are Changing." At the left the scene switches to the deck of the Cherokee. From this vantage point the shipbuilding yards and Naval concentration were explained by an expert running commentary. Wives came along on this tour before docking at the Chamberlin for the traditional scene below, the evening cocktail party. The Chesapeake & Ohio Railway Co. sponsored this fete. The fall conference was sparked by such features.

The first session Thursday morning was held in the Roof Garden of the hotel. Arthur J. Stock (below), president of Stock Equipment Co., was the first speaker, and his remarks sparked some discussion. After a coffee break, L. E. Mylting (bottom), Allen-Sherman-Hoff, spoke on handling and waste problems.

Speaker at the first technical session was Walter Gruca, Standard Forgings Corp. H. Vaughn Mansfield and T. S. Spicer were co-chairmen of the early morning mine session.

Shots of the field trips to Indian Creek and Meremac caught W. B. Stephenson, J. C. Fox, W. Basler, Pauline Moyd, Dorothy Gore, R. Grogan, and Dusty Rhodes enjoying an outdoor luncheon.

"St. Louie" Welcomes Mineral Men in October

The Mid-America Minerals Conference completed a successful program October 25 in St. Louis, after three days of technical sessions, field trips, and social events. Meeting headquarters were the Chase and Park-Plaza Hotels and the St. Louis Section was host to the gathering.

Chairman of the conference was G. Donald Emigh, St. Louis Section chairman and SME Vice President, and his associate officers of the Section were responsible for meeting arrangements.

The meeting began Thursday morning with a field trip and two technical sessions on the agenda. The coal field trip visited the Peabody Coal Co. in Freeburg, Ill., to see the mine and barge-loading facilities, while the sessions for minerals beneficiation and geology and geophysics were being held in the Chase Hotel. Simultaneously the women enjoyed a coffee hour.

Everyone gathered together for the welcoming luncheon in the Khorassan Room after the morning activities. The Honorable Raymond R. Tucker, Mayor of St. Louis, welcomed those attending, and Felix Wormser, vice president of St. Joseph Lead Co., gave an address on metal industry economic conditions.

Speakers at simultaneous sessions are Virgil Lessels, above, and J. C. Bradbury.

At the coffee hour Mrs. Bell (standing) chats with Mrs. Weigel and Mrs. George, while Mrs. Kesler listens. Below, the line-up reads J. D. Forrester, G. Bell, R. B. Ladoo, J. C. Fox, G. D. Emigh, and R. Feierabend. The corner shot shows Dort Tikker.

The Chase Hotel was the home for Thursday's sessions. Luncheon in the Khorassan Room featured Felix Wormser, top left, discussing economic conditions in the metal industry. Considering coal economics is W. H. Voskuil, above, at an afternoon session in the Regency Room. Still later in the day good friends gathered together before dinner to discuss the events of the conference. Pictured below at the cocktail party sponsored by companies in the St. Louis area are J. D. Grace, H. N. Propp, S. C. Judge, and B. F. Buff. Many informal moments cemented friendships at the meeting.

In the afternoon the mining session and coal session took place and a cocktail party wound up the day.

On Friday a variety of field trips had been arranged for members to select. An all-day mining and milling tour covered the Indian Creek Mine & Mill of St. Joseph Lead Co. The extractive metallurgy field trips went to Granite City Steel Co. or to Dow Chemical Co. And the industrial minerals field trip viewed the Missouri Portland Cement Co.

Technical sessions for industrial minerals and extractive metallurgy plus a luncheon and fashion show for the ladies filled the afternoon. In the evening a special feature of the program was the dinner-dance, with guest speaker Augustus B. Kinzel, President of AIME. Donald Emigh gave welcoming remarks before Mr. Kinzel's address entitled *Metals, Missiles and Men*. Dancing until 1:00 a.m. ended the busy schedule for the day.

On the final day of the conference an Iron Symposium was held, with sections devoted to supply, geology and prospecting, drilling, mining, milling, and utilization. Chairman of this session was Robert Geehan, chief, Div. of Mineral Technology, U. S. Bureau of Mines in Rolla, Mo. The ladies, meanwhile, wound up the convention with a tour of St. Louis by bus. Mrs. N. L. Shepard and Mrs. G. M. Bell deserve the credit for the female portions of the program.

The work of many members and the support of many companies in the St. Louis area contributed to make the conference worthwhile.

The lighter side of the conference is evidenced in these candid shots. The purpose of these gatherings was sheer conviviality. Mr. and Mrs. J. E. Phebus, above left, share the conversation with Mr. and Mrs. Tom Lake. The distinguished group posing below are F. B. Moodie, Jr., William T. Rule, William D. Cunningham, Don B. Saxby, and F. B. Moodie, III. And at the left a warm welcome from the city of St. Louis was offered by the Honorable Raymond R. Tucker, mayor, at the opening luncheon.

Around the Sections

The Lima, Peru, Section celebrated their 60th luncheon on July 16. Seated clockwise above are Edgardo Portaro, Bill Gibson, Henry G. Smith, Albert H. Barrios, Bernard T. Colley, Walter E. King, Richard N. Spencer, Fred Gerbracht, and Lawson P. Entwistle.

• The **Coeur d'Alene Subsection's** (Columbia Section) midsummer dinner-dancing party was held August 9 at the Shoshone Country Club near the famous Sunshine mine. Co-chairmen James B. Colson and James E. Ringel arranged all details with finesse, with dark-of-the-moon contrasting with sparkling ice cubes. A midnight buffet prepared the group to face the dawn.

• The 60th monthly luncheon meeting of the **Lima Peru, Section** was held on July 16 at the Hotel Bolivar, with a special welcome to guests and to Bernard T. Colley, Legion of Honor member, who was visiting in Lima. Henry G. Smith spoke on *What Industrial Engineering Can Do For You*. Albert H. Barrios is the new chairman who presided at the meeting.

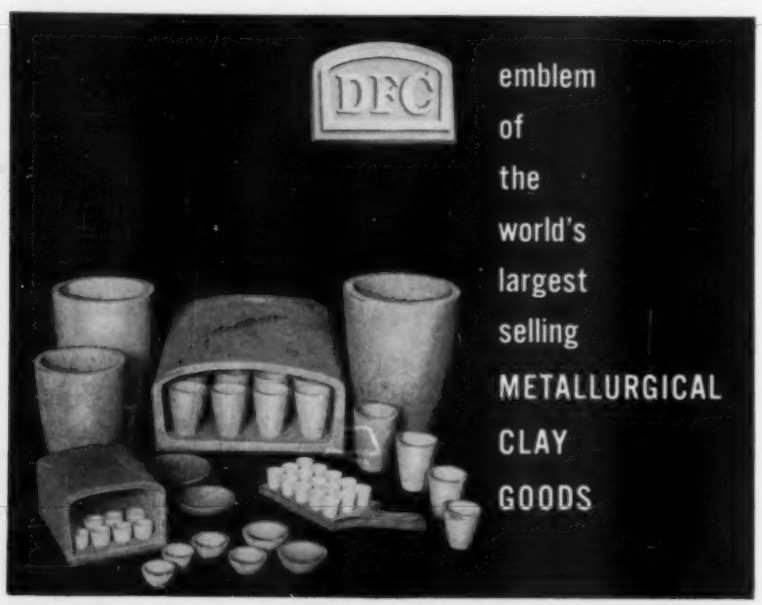
The **Southwestern New Mexico Section** held its annual picnic at the Cameron Creek Picnic Grounds on Saturday evening, June 7. The members and guests brought their own box dinners and the Section furnished steaming coffee, cold drinks of pop and beer. The families enjoyed getting together and the wonderful weather made a pleasant atmosphere for a summer outing.

• President's Night, the national officers' meeting in November of the **Ohio Valley Section**, was honored this year by the presence of Dr. and Mrs. Augustus B. Kinzel, President of AIME. The meeting was sponsored jointly by the Ohio Valley Section, and the Columbus Chapter of WAAIME. A special luncheon was planned for Dr. Kinzel and the Section executive committee, with local business leaders invited. The dinner meeting was at Ricardo's, Columbus, Ohio, where both Dr. and Mrs. Kinzel spoke.

• The **Mexico Section** held a meeting on August 11 at the University Club, Mexico City. Eduardo Guzman, president of the Section, opened the meeting and announced fall plans for the arrival of AIME President Augustus B. Kinzel. He introduced the evening speaker, Carlos Graef Fernandez, director of the faculty of sciences of The Autonomous National University of Mexico, who spoke on *Pacific Uses of Atomic Energy*.

A festival was held on August 15 with films on Mexican folklore.

• The **Colorado Plateau Section** gathered at Muddy Springs Picnic Grounds for a pleasant summer meeting on August 16 with a western-style barbecue. Joseph Gillson, Vice President of AIME, gave a special talk to the picnicking engineers and their families.



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Personals

F. PARDEE

J. FUCHS

Franklin Pardee has retired as president of the American Iron Ore Assn. in Cleveland and has opened an office for consulting mining geology. His home is in Crystal Falls, Mich.

Jerome Fuchs has been appointed manager, systems and procedures for American Metal Climax Inc., New York. He had held the same position with Penn-Salt Chemicals Corp.

Rudolph C. Gebhardt, geologist and mining engineer, has been named manager of the Mining Div. of the E. J. Longyear Co., Minneapolis, to succeed **Donald M. Davidson** who became president. Mr. Gebhardt was senior geologist and mining engineer in charge of the Denver consulting office of the company.

H. K. Cogswell has been appointed eastern regional sales manager for the Western Machinery Co. New York will be his headquarters as he oversees company sales operations in the eastern states. He had been field sales engineer for the southwest territory with headquarters in Phoenix, Ariz.

R. C. GEBHARDT

H. K. COGSWELL

Lewis B. Harder, president of South American Gold & Platinum Co., was elected chairman of the board of International Mining Corp. He is also a director of Placer Development Ltd. which will work closely with the corporation. International Mining Corp. is expanding into natural resources.

N. M. LEVINE

C. R. WALBRIDGE

Nathan M. Levine has joined the Technical Div.'s Development Dept. of Stein Hall & Co. where he will be responsible for developing the use of Jaguar, Stein Hall's line of guar gums, in mineral dressing, flocculation, and as a filter aid. He had been working on beneficiation problems of copper and cobalt ores for the Howe Sound Co., Salt Lake City.

Cecil R. Walbridge, after 20 years of service in the Denver district sales office of Worthington Corp., where he was district manager, has resigned to establish his own business in Denver.

Clare E. White has been elected president and chief operating officer of the Ungava Iron Ores Co., Montreal. He had been general manager of United Keno Hill Mines Ltd.

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PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company

Former Title ..... Length of Time There

New Company

New Title ..... Date of Change

Any recent activity that would be of interest to members:

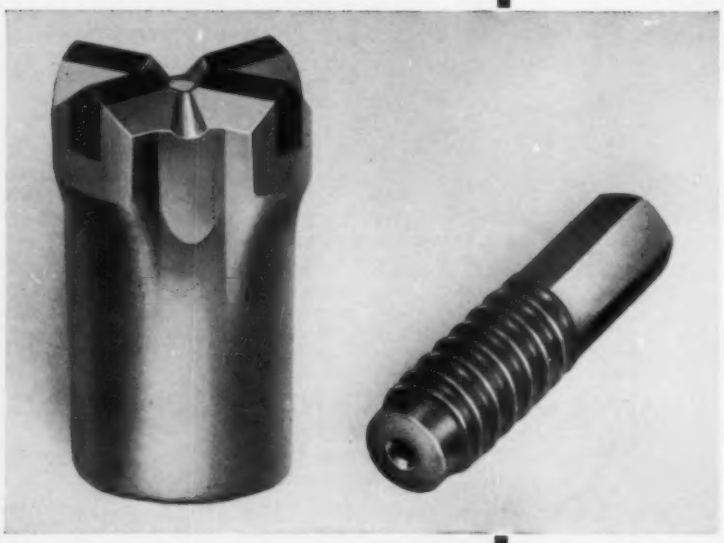
personals

continued

William C. Hayes, Jr., economic geologist for the Missouri Geological Survey, has been named assistant state geologist. He is a specialist in economic geology and has worked extensively with iron ores. He replaces **G. A. Muilenberg,** who has retired after ten years' service.

Lester R. MacLeod retired Aug. 1, 1958, from the Anaconda Co., N. Y. His entire career, except for three years with Boeing Airplane Co., has been with Anaconda. He had major responsibility for mechanical design and selection of crushing and conveying equipment for many plants. Mr. and Mrs. MacLeod have moved to Prescott, Ariz., to enjoy golf and fishing with limited dabbling in engineering.

Michael A. Price has become mine superintendent for Vitro Uranium Co. in Green River, Utah. He had been mine foreman for Temple Mt. Mines.



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H. E. JOHNSON

R. O. BAUM

Hugo E. Johnson has been elected president of the American Iron Ore Assn. to succeed Mr. Pardee. He has been with the association since 1954, first as vice president and more recently as vice president-secretary.

Rolland O. Baum has been elected president of Tennessee Products & Chemical Corp., Nashville, Tenn., to succeed **Carl McFarlin, Sr.,** who was named chairman of the board, a newly created post. Mr. Baum had served as executive vice president and general manager. Mr. McFarlin has served as president since 1939, the year after he joined the company when the firm he had founded, the Whitwell Smokeless Fuel Co., was purchased by Tennessee.

Bob Watson, former party manager for Petty Geophysical Engineering Co., has been appointed field service engineer in the Rocky Mountain area, operating out of Casper, for Herb J. Hawthorne Inc.

C. McFARLIN SR.

R. A. WATSON

Donald F. Redfearn, who had been a student at the Missouri School of Mines, is now a field engineer for Hughes Tool Co. in Clay City, Ill. He will move to Houston in January to work in the factory where Hughes' rock bits are manufactured. He will be there a year before returning to field work at Clay City.

Henry C. Rose, for the past seven years president of Pittsburgh Coal Co., Div. of Consolidation Coal Co., has retired for reasons of health. He had been employed in positions of increasing responsibility at Pittsburgh Coal since 1928, shortly after his graduation from Ohio State University. He will be succeeded as president by **George O. Tarleton,** vice president of consolidation, and formerly president of the Kentucky Div. Mr. Tarleton will have his headquarters at Library, Pa.

The Cleveland-Cliffs Iron Co. announced the appointment of **James**

S. Westwater as vice president-mining, to succeed **C. W. Allen,** who has resigned to take a position with the U. S. Government. Mr. Westwater has been manager of the Michigan Mines for the company since 1953. Mr. Allen's new work will be with the Industry Resources Section of the International Cooperation Administration in Washington, D. C. **Hugh J. Leach,** who has been manager of Cliff's Minnesota mines, has been transferred to Ishpeming, Mich., to manage the Michigan mines. **John J. Foucault** will succeed Mr. Leach in Minnesota, and **Stanley W. Sundeen,** formerly manager ore development, will be manager, research and iron ore development for Cleveland-Cliffs, where Mr. Faucault had been superintendent.

William C. Maher has left the U. S. Navy and joined Standard Slag Co. as junior engineer in Gabbs, Nev.

John W. Gabelman is a geologist for the U. S. Atomic Energy Commission, Div. of Raw Materials. He had been in the Grand Junction Operations office and now will aid the Peruvian Junta de Control de Energie Atomic in the appraisal of uranium deposits, and will assist the representative of the Div. in Latin America, with headquarters in Lima, Peru.

Theodore F. Berthelote, formerly assistant mining engineer for the Anaconda Co., has recently completed a course in meteorology at the University of Utah where he received a B.S. He is now assigned to weather research at Geiger Field for the U. S. Air Force and resides in Spokane.

E. H. Lindsey, formerly associated with The Anaconda Co., is now with Wisser & Cox, consulting geologists, San Francisco. At the University of California he recently completed two years graduate study in geochemistry and rock alteration with particular reference to copper ores.

G. F. Coope, formerly president of Potash Co. of America, retired in August but remained on the board of directors and the executive committee of the company, and will also be a consultant. Mr. Coope has been with the company almost 22 years. **F. O. Davis,** executive vice president and treasurer, became the new president of the firm.

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Obituaries

Frank F. Grout

An Appreciation By
George A. Thiel

Frank Fitch Grout (Member 1918), geologist and petrographer in the Dept. of Geology and Mineralogy at the University of Minnesota for nearly half a century, died Aug. 1, 1958. Dr. Grout was born in Rockford, Ill., Jan. 24, 1880. He received his B.A. degree from the University of Minnesota in 1904, and an M.S. degree in 1908. Yale University conferred a doctorate degree in geology in 1917. Prior to receiving his Ph.D., he served with the West Virginia, the Illinois, and the U. S. Geological Surveys, and taught mineralogy at the University of Oklahoma. He joined the staff of the geology department at the University of Minnesota in 1907 and attained the rank of professor in 1914. He held this position until his retirement in 1948.

Following his retirement, Dr. Grout taught as visiting lecturer at Florida State, Columbia, and Arizona Universities, and the California Inst. of Technology. He was an active member of many scientific societies including the Geological Soc. of America, for which he served a term as counselor; the Soc. of Economic Geologists; the National Research Council; the American Chemical Soc.; the Mineralogical Soc. of America; and member of several European geological societies.

Dr. Grout's research interests were broad and varied, and his bibliography includes scores of titles, dealing with various aspects of earth science. Early in his career he studied clays, shales, and coral but later his interests centered on igneous petrology and metalliferous ores. His most recent articles in that area dealt with the formation of igneous rocks by metamorphism and the origin of granite.

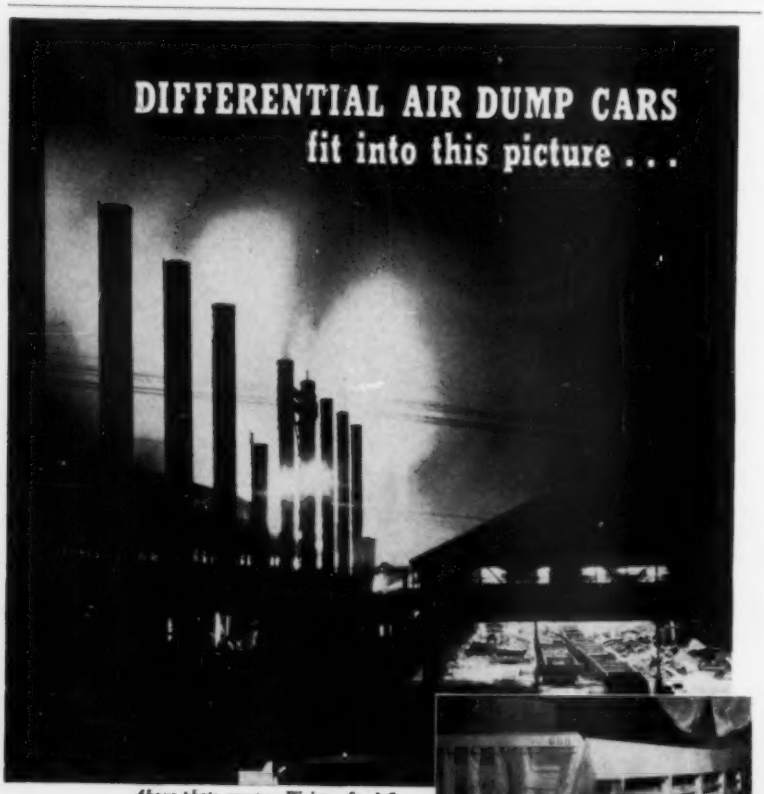
Dr. Grout served as acting director of the Minnesota Geological Survey from 1945-1947. Many of the titles in his bibliography involve studies of the igneous and metamorphic rocks of the pre-Cambrian of northern Minnesota. Included in these studies were reports on the iron formations of the Lake Superior region and details on the petrography of taconite. His findings on the taconite of the east Mesabi led to preliminary attempts at magnetic concentration of iron ore at the Mines Experiment Station of the University of Minnesota, a method adapted at the station and now used commercially.

Joseph F. Thorn (Legion of Honor Member 1906) died on Oct. 25, 1957, in Millendon, W. Australia. He was born in California in 1878 and worked in various positions as shift boss, general manager, and mine superintendent, the latter in Chittabalbie, Korea. He also worked in Nevada, California, and Mexico before becoming general manager of Lake View and Star Ltd. in Western Australia. He was a member of The Australasian Inst. of Mining and Metallurgy.

George G. Titzell, Jr. (Member 1916), died in San Francisco on May 27, 1958. Born in Kittanning, Pa., in 1892, Mr. Titzell was a graduate of Yale Sheffield Scientific School with a degree in mining engineering and was with the U. S. Steel Corp. until he joined the Air Force in World War I. He rejoined U. S. Steel and

Necrology

Date Elected	Name	Date of Death
1958	Eugene Childers	Sept. 15, 1958
1942	Roy L. Cornell	Unknown
1948	Stewart J. Cort	Sept. 23, 1958
1939	V. A. Crosby	Oct. 2, 1958
1930	Collis E. Druley	June 27, 1958
1949	J. A. Hammond	Feb. 1, 1958
1952	Harry A. Harper	June 14, 1958
1896	Martin J. Heller Legion of Honor	Oct. 17, 1958
1956	J. M. Johnson	Apr. 24, 1957
1920	F. N. Meyer	July 24, 1958
1914	George R. Rogers	Dec. 6, 1957
1953	T. R. Weymouth	Sept. 23, 1958



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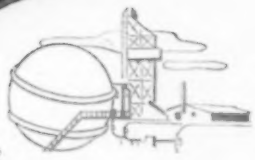

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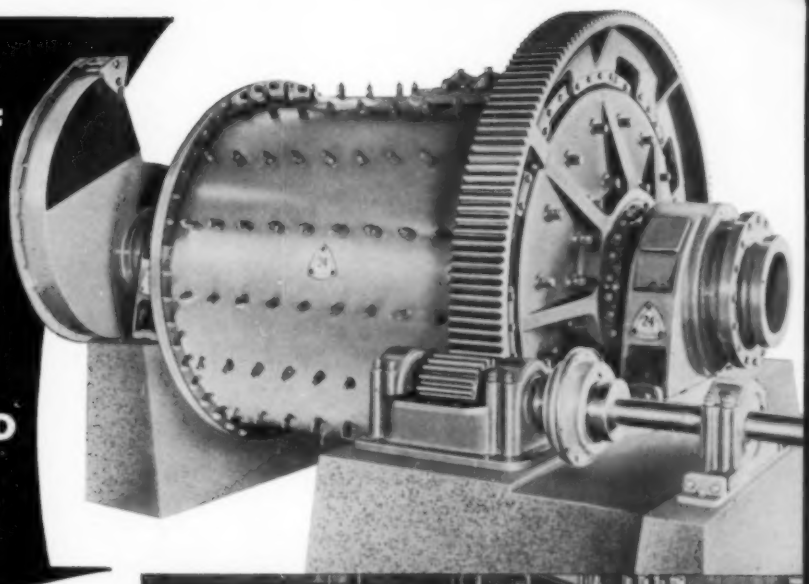

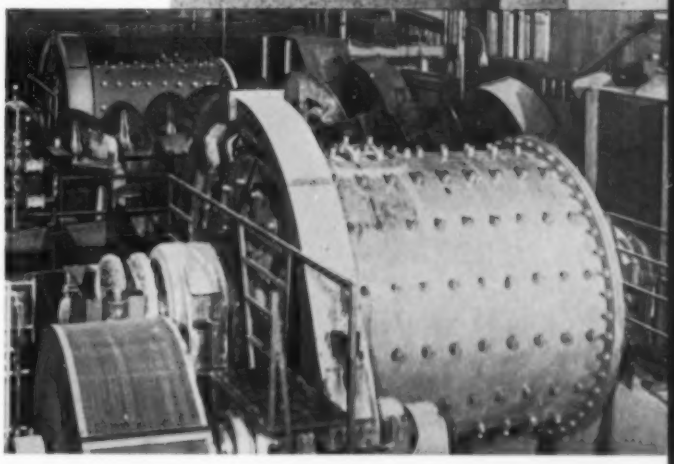

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